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THE JULY SCIENTIFIC MONTHLY

EDITED BY J. McKEEN CATTELL

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THE SCIENTIFIC MONTHLY

JULY, 1932

MEDICAL AND OTHER CONDITIONS IN SOVIET RUSSIA

By LEWELLYS F. BARKER, M.D.

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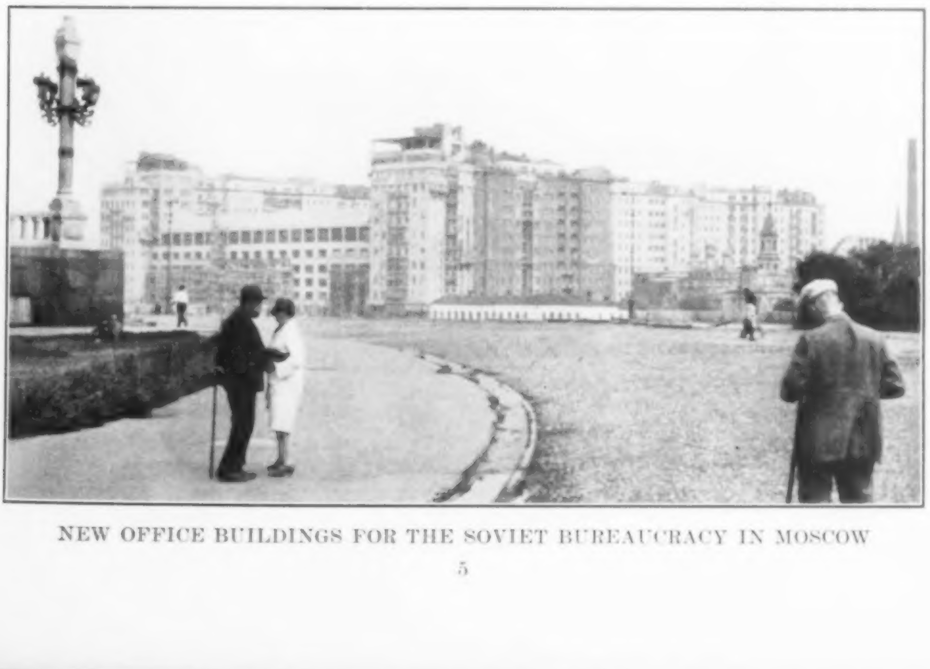
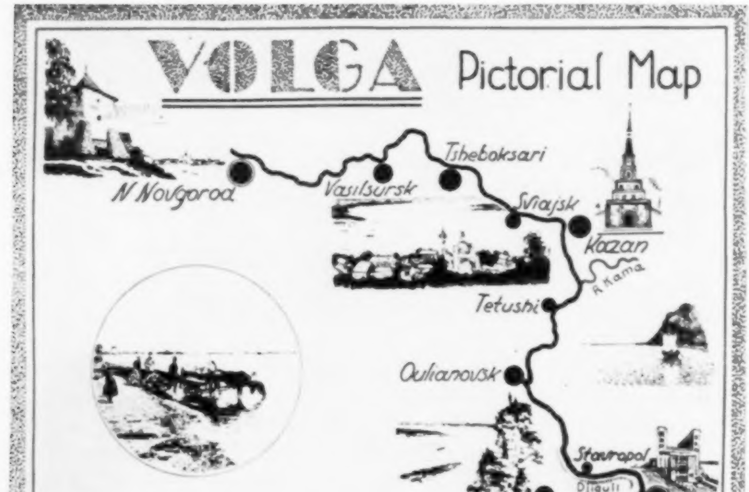
In a recent volume, "The History of the Russian Revolution," Leon Trotzky, now in exile, points out that backward countries, although compelled to follow after advanced countries, do not take things in the same order. Rather it is a privilege of historic backwardness to permit, or rather to compel, the adoption of whatever is ready in advance of any specified date, skipping a whole series of intermediate stages, the development as a whole thus acquiring a complex, combined character. Though this author was thinking chiefly of political and economic development, the principle he refers to has certainly been strikingly illustrated in the development of medical activities in Russia since the Bolshevik revolution. There has been not only a great leap forward in the adoption of many of the better measures of public health worked out in more advanced countries, but Soviet Russia, through the leadership of its first commissar of health, Dr. N. A. Semashko, has initiated a number of public-health measures that are unique and make a certain appeal to the countries in which cultural develop-



NEW OFFICE BUILDINGS FOR THE SOVIET BUREAUCRACY IN MOSCOW



THE VOLGA TRIP
(NIJNI-NOVGOROD TO STALINGRAD).

ment in general has reached a far higher stage than in Russia.

During the past summer, my wife and I flew from Berlin to Moscow and joined a party of eight, under the leadership of Dr. David Ostrinsky, of New York, for a twenty-five day tour through Soviet Russia. In this article I shall mention some of the impressions we formed of medical and other conditions now prevailing in Soviet Russia. I was permitted to take several hundred photographs, and from these I have selected a number that illustrate objectively some of the conditions as we ourselves saw them; from them, readers may form judgments for themselves regarding the appearances as seen through the eye of the camera.

Many of our friends were dubious as to the safety and the value of a trip to Soviet Russia at this time. Some of them even feared that we might be in danger of our lives, or that we would become ill because of food conditions and of the discomforts of traveling; others were of the opinion that the trip would scarcely be worth while, since they believed that we would be "led about by the nose," would be shown only things that the authorities were willing for us to see and would not be permitted to visit persons or places except when accompanied by official guides and under the surveillance of the much-dreaded Secret Police (G. O. P.)

On reaching Russia, however, we discovered that these ideas of danger and of limitation had been greatly exaggerated. We were everywhere treated with courtesy and consideration. We were allowed to move about freely and in no instance were we prevented from visiting persons or institutions that interested us. If we were under close supervision, this was neither obvious nor obtrusive. I was permitted, as I have said, to take photographs freely, the only interdiction being photography of railway stations, fortresses and the Red Army; the authorities retain the privilege, however, of inspecting the developed films before they are taken out of the country.

Most tourists, it is true, are accompanied everywhere by official guides and interpreters, since very few of the foreigners entering the country speak Russian. We were fortunate in having most intelligent guides, who were tireless in helping us to make the most of our trip. My wife and I spoke no Russian, but we both speak some German and a little French, and I visited a number of university professors, medical clinics, research institutes and the Academy of Sciences entirely unattended. Since it was possible, on these visits, to converse in English, German or French, I got, I believe, a very fair impression of the medical and scientific situation as it exists, especially in Moscow, Leningrad and Odessa. Medicine is a kind of free-masonry and medical men are prone to talk with one another quite freely; the Russian physicians and scientists with whom I conversed seemed to me to be entirely frank in their discussion of conditions. Many of these were not members of the Communist Party. Indeed, some of them had been strongly opposed to the Revolution, though they have, since its victory, adapted themselves to the new régime. My wife and I had the privilege of dining with one of the professors of medicine and his family in Moscow, and thus got a glimpse of the actual home life of an important medical man. With the Reverend Dr. Lindsay, of Brookline, Massachusetts, I visited in the suburbs of Moscow a young worker who, with his wife and child, occupied a one-room apartment in a three-family cottage; we took afternoon tea and discussed their mode of life with them. We had many other opportunities freely to examine, without supervision, certain situations in which I was interested.

The food supplied, though sometimes

THE KREMLIN IN MOSCOW

A DROSCHKE FOR HIRE (MOSCOW)

monotonous and not always attractively served, was sufficient. A professor from the University of Pennsylvania told me that he had been a chronic dyspeptic all his life, but that during his trip through Russia he had been entirely free from symptoms of indigestion! The circumstances of travel, though, of course, very different from those to which we are accustomed in America, were everywhere tolerable. As a matter of fact, we gained the impression that the authorities of Soviet Russia welcome American tourists and try to make their sojourn in the country as comfortable and as interesting as possible for two reasons: (1) In the absence of diplomatic recognition, they feel that Americans have very wrong impressions of the conditions that exist, and (2) they hope that tourists will, while in the country, spend some of their foreign money in addition to the actual cost of the trip paid before entering the country, since the authorities are very desirous of acquiring *valuta*, with which they may make purchases of machinery and other supplies from outside and may pay salaries to the foreign experts now at work in helping them to develop their natural resources.

Our tour included approximately a week in Moscow, a few days in Leningrad, a visit to Nijni-Novgorod, a four-day trip down the Volga River to Stalingrad, a day in Rostov, and a few days in Sochi on the Black Sea, in the Crimea, and in Odessa, after which we returned to Europe by way of Poland and Vienna.

RUSSIAN GUIDES

Though they do not use the terms "first, second and third class" for travel in Russia, one can travel by "category P, category W, or category T," which correspond to different prices and comforts. Our party chose category W, which gave us soft cars on the railway, whereas category P supplies international Pullmans where they are available, and category T means traveling "hard." On occasion, we found it desirable to pay a supplement in order, on

long journeys, to travel in international sleeping cars.

The most contradictory views exist among intelligent people in America as to the nature and outcome of the economic and social experiment now under trial in Soviet Russia. Among the several views expressed, there are four, as Brandt has pointed out, that seem to be more widely held.

In the first place, there are many who feel so certain that the Russian experiment is doomed to total failure and soon that they think any serious discussion of it merely futile; but it should be recalled that the Soviet government now in power has held office for nearly fifteen years, longer than any other cabinet in Europe, and we gained the impression that it is likely to remain in power for a long time, zigzagging so as to go now to the "right" and now to the "left," and making whatever compromises are necessary to hold the support of the masses. An American engineer who had been long in Russia told me that he considered the Soviet government the most stable in Europe at the present time.

A second view, held by some of those who sympathize warmly with the Soviet régime, sees Russia as a kind of earthly paradise in which there is plenty of good food, no unemployment and equality of wealth and opportunity for all. An actual visit to Russia ought to temper such a view, since, as I have said, the food is none too good and none too plentiful. Though great strides have been made toward equalizing opportunities, it is, as far as wealth is concerned, equality of impecuniosity that has thus far been achieved. That unemployment is, however, practically nonexistent must be admitted; and Soviet Russia, in this respect, is in marked contrast with the rest of the world in the present economic crisis.

A third view that is widely held is that Russia, through alleged enforcement of labor, the Red army and restriction of expenditures to the development of its industry and natural resources, is becoming a definite economic

A STREET SCENE IN MOSCOW

WAITING QUEUE IN FRONT OF A COOPERATIVE FOOD STORE

and military menace to the rest of the world. But those who hold this view seem to forget the very backward state of Russia, the distance she has to travel before catching up with the achievements of capitalistic countries, and the difficulties that must be overcome in changing an illiterate peasant population into an educated industrial people. During the revolution and the years that immediately followed, Russia lost many of her prominent business men, many of her engineers, many of her skilled workers and many of the intelligentsia, through death or emigration. She is making strong efforts to meet the situation by saving every kopeck possible for the development of great industrial plants and cooperative farms, and for the payment of experts and skilled workers imported from abroad; but even her leaders admit that she has poor transportation facilities, that there is much mismanagement, that there is still appalling waste, and that the quality of production is far from what is desired.

GIRLS SELLING FLOWERS IN MOSCOW

STREET SCENE IN MOSCOW
WITH VICTORY ARCH IN THE DISTANCE.

STREET SWEEPER IN MOSCOW

It looks as though it would require two or three generations, at least, to bring society and industry up to standards anything like those of the West. Communism has, temporarily they say, been given up for a kind of State Capitalism, with some small-scale private capitalism still permitted; they expect later on to pass from this through an ever-increasing socialistic régime to the ultimate goal of Communism. Meanwhile, there would seem to be very little menace to other countries, either from the economic or the military side. Russia does not want war; what she wants is to be left alone in order to develop. Nor has she, in my opinion, money to spend on propaganda for the fomentation of revolution in other countries, contrary to what is generally supposed.

A fourth view, attributed to Colonel Hugh L. Cooper, the distinguished American engineer who is supervising the building of the great dam upon the Dnieper River, which is to supply electrical power for the Ukraine, is believed by Mr. Brandt, of the *St. Louis Post Dispatch*, to be most in accord with the facts. Colonel Cooper, who has formed a close friendship with Stalin, is of the opinion that Stalin differs from Lenin in that he thinks the Soviet régime can succeed without world revolution and that her best course is to "cultivate her own garden" and to avoid stirring up revolution in other countries. If this attitude should be maintained by Stalin and his successors, Colonel Cooper believes that, through the development of the heavy industries and through intensive cultivation by State and cooperative farms, Russia will not only survive, but will gradually reach a much higher state of wealth and of culture. During the period of her development, however, and as conditions gradually improve, there will be an increasing demand for comforts and luxuries, which Russia, herself, will not be able to supply. She ought, therefore, to afford a vast market for Western Europe and for America for at least two or three generations. My own observations while in Soviet Russia made me agree with Mr. Brandt

A STREET SCENE IN MOSCOW

Crowd around a man selling a few cucumbers and tomatoes. Note the cobble-stone streets. Since our visit the streets in Moscow have been repaved.

that Colonel Cooper's view is more in accord with the situation than the other three views referred to. On talking with Mr. Walter Duranty, the correspondent of the *New York Times* in Moscow, I found that he also leaned to this opinion.

General Conditions in Soviet Russia

On entering Russia, one's attention is directed at first, of course, to the general situation—to the appearances of the streets, the shops and the people. The photographs that illustrate this article will give, perhaps, a better impression of these than any detailed description. One can not help but be struck by the primitive character of the pavements, the drab appearance of the streets, the emptiness of the shop windows, the long queues of people standing in the streets in front of cooperative stores, carrying their baskets for holding food rations, the crowded street cars, the aggregation of people in gossiping groups and the characteristic headwear and footwear. One sees very few horses and carriages and almost no automobiles, except the few that belong to officials and to the tourist agency. The Russians simply can't believe that we have twenty-six million private automobiles in use in the United States!

A striking feature is the absence of class distinctions in the way of dress or bearing. The people look as though they all belong to one class (as theoretically they do). In hotels and restaurants, one is waited upon by men with rolled-up sleeves and turned-in shirts, or by men in blouses. The table-cloths sometimes show the spots of many preceding meals.

TRAVELING ACTORS FROM MOSCOW

MAKING THE ROUNDS OF THE COOPERATIVE FARMS AT HARVEST TIME.

Women are on an equality with men, and the women, both married and single, are all at work as the men are, the married women leaving their young children in the factory *crèches* when they go to work. I may cite one interesting example of what this equality means. One day in Moscow, while seated in a street

GREAT ACADEMIC STATE THEATER IN MOSCOW

car, a young woman entered, and, as every seat had been taken, I rose and offered her my seat, which she declined. My companion, who knew Russia well, told me that I had "insulted" this young woman, that she was strong and well and, therefore, my "equal." Had she been a very old, feeble woman, or a young woman who was obviously sick, or pregnant, my offer would not have been regarded as insulting! I was told that a woman who is pregnant carries a pregnancy card and, on entering a street car in which no seat is available, the conductor on presentation of the card, arranges that she may have the privilege of

REGISTRY OFFICE

FOR MARRIAGES AND DIVORCES IN MOSCOW.

A WAIF GIRL

IN FRONT OF THE GRAND HOTEL IN MOSCOW. MOST OF THESE WAIFS ARE NOW HOUSED IN ORPHANAGES.

standing in one corner of the platform where she can support her back, or has a seat vacated for her.

The art treasures of Russia are being preserved. Indeed, the great galleries, like the Hermitage in Leningrad, are more valuable now than before the revolution, since the private collections were confiscated and the best pictures put into the State galleries. Music and the theater are well supported, and workers in the factories are given tickets, either free or at reduced rates, for notable performances and concerts. During the summer, troops of actors from Moscow and Leningrad travel in box-cars through the country districts and give entertainment to the agricultural workers. Music sometimes has to take the place of good food; I remember particularly, while eating a rather bad dinner in one of the smaller cities, that we had the pleasure of listening to an excellent orchestra of eight pieces!

Marriage is made very easy; the two who desire to marry present their workers' cards at a registry office, pay a small fee and are recorded as man and wife, no religious ceremony being necessary. Divorces are equally easy when they are desired, but there are strict rules with

COMMUNITY SINGING IN MOSCOW

regard to making provision for the maintenance of the children of the divorced persons.

The Soviet authorities adhere to the doctrine of "dialectic materialism" and insist upon the teaching of this in all schools. Religion seems to be anathema to them, and the statement of Lenin that "religion is the opiate of the people" is often cited. The orthodox church in Czarist times was in close league with the Czaristic government and the aristocracy; it was functionally scarcely religion in the sense that we understand it. The people were, therefore, willing to see the religious organizations disappear along with the Czarist government. Many of the cathedrals and larger churches have been converted into anti-religious museums or into workers' clubs. The beautiful Cathedral of the Redeemer in Moscow, a photograph of which I took, has, since our visit, been torn down to make room for a new Soviet palace of labor. People may still have church

CATHEDRAL OF THE REDEEMER

THIS HAS BEEN DEMOLISHED SINCE THE PHOTOGRAPH WAS TAKEN TO GIVE PLACE TO A SOVIET PALACE OF LABOR.

GROUP OF WOMEN PRISONERS

WOMEN'S PRISON IN MOSCOW

services, however, if 30 per cent. of the previous membership desire them. As a substitute for religion, enthusiasm for socialism and communism is systematically cultivated.

The imagination of the youth of Russia has undoubtedly been captured. They are enthusiastic about the five-year plan, proud of the present achievements of collectivism and are full of hope for a very bright future. A large part of the youth is thoroughly organized in three groups: The *Comsomols* (16 to 24), the *Young Pioneers* (8 to 16), and the *Octobrists* (4 to 8). Members of the Communist party instruct the Comsomols, the Comsomols instruct the Young Pioneers, and the latter instruct the little Octobrists. From these youth organizations, the Communist Party (with less than three million members now) will later be greatly augmented. The young

ST. ISAAC'S CATHEDRAL IN LENINGRAD

NOW CONVERTED INTO AN ANTI-RELIGIOUS MUSEUM. STATUE OF PETER THE GREAT ON THE LEFT.

people have many processions with flags and banners and they love to sing revolutionary songs. Most of these youngsters appear to be hilariously atheistic. Several of them asked me if it were really true that people in America still believe in God! The young people are also fiercely anti-capitalistic and are taught to believe that the world revolution is near. I was asked more than once when the revolution was coming in America; they seemed to think it was "just around the corner." They are taught to believe that all they can expect from the capitalistic countries is a

NIJNI-NOVGOROD IN THE DISTANCE

NEAR THE SITE OF THE NEW FORD AUTOMOBILE FACTORY.

revolver pointed at their breasts. Fear of attack by capitalistic nations is evidently promulgated with the idea of keeping up enthusiasm for the Soviet régime.

American engineers and skilled workers are highly prized in Soviet Russia. Men like Colonel Cooper and John Calder are looked upon as miracle-workers, for they have met and have overcome very great difficulties. In a recent play, entitled "Tempo," a Russian playwright, Nikolai Pogodin, has depicted the work of John Calder (under the name of "Mr. Carter") very vividly, and the audiences are said to greet with enthusiasm the acts in which this American engineer exhibits an inexorable will in achieving successes, despite the many obstacles that dismay the Russian workers.

Medicine in Soviet Russia

Among the greatest of the changes produced in Russia by the Revolution has been the complete transformation of the medical situation. The desire to understand this, and to see for myself how it worked, was, especially after talking to Dr. W. H. Gantt, one of the principal motives of my trip.

I did not have the privilege of seeing Russian medicine under the old régime, but there is an interesting account of it in Colonel F. H. Garrison's recent ar-

ticle. Medical schools and hospitals in pre-revolutionary days were good, but there were too few of them. Excellent research work was carried on in important institutes of investigation and the names of Pavlov, Metchnikoff, Pirogoff and Filatow were world-famous.

But, in 1913, there were less than 13,000 physicians in the whole of Russia to care for a population of 150,000,000 people, and the majority of these were in the cities, so that the peasant population got but little medical attention. In some country districts there was only one physician to 30,000 or 40,000 people. Semi-trained men and women, known as *feldschers* and *feldscheritzas*, took care of emergencies, performed minor operations and had some skill in caring for the commoner diseases. Trained nurses were rare outside of the cities.

The death rate in Russian hospitals was high, especially in smaller places, and the infant mortality rate was the highest of any civilized country, being over twice as great as that of England and more than four times that of Norway. There was no central health organization and the private institutions and private practitioners did not work according to any common standard.

The Nationalization of Medicine: About the middle of 1918, medical institutions and the treatment of disease were nationalized in Soviet Russia and made a function and responsibility of the State. Semashko was appointed commissar of health and undertook this nationalization and socialization of medicine, asserting that medicine should be unified, that medical aid should be made accessible to all citizens, that medical treatment should be free for all, that the medical personnel should be suitably qualified, and that the main emphasis should be placed upon disease prevention. It was his plan to make all doctors, feldschers, nurses and pharmacists civil servants, and to see to it that all

GROUP OF WORKERS
WATCHING A PHOTOGRAPH BEING TAKEN (LENINGRAD).

hospitals, sanatoria and drug-stores should be State institutions. He realized the necessity of greatly increasing the number of available physicians and of medical institutions. Though he hoped ultimately to make all medical treatment free, he had to be satisfied with the compromise of providing free treatment for holders of health insurance, for soldiers and their families, for school children and for the poorest peasants. From the very first he laid stress upon the introduction of prophylactic measures for the reduction of the incidence of tuberculosis, venereal disease and epidemics, and he undertook, as rapidly as possible, wide-spread propaganda for the instruction of the people in the methods of maintaining positive health.

It was not until five years after the Revolution, however, that any well-organized form of State health insurance could be undertaken. Though the general principles and the coordination of this work depended upon central headquarters in Moscow, the actual provisions for health service had to be allotted to clinics and institutions of local health departments, the latter receiving subsidies from insurance funds. Against much opposition on the part of the medical profession, a Medical Workers' Union was organized to include doctors, nurses, druggists, laundresses and chauffeurs; prejudices against this union were gradually overcome and the meetings of the combined medical personnel led to a better understanding of the medical situation and to better cooperation among the different groups.

This commissar of health, Dr. N. A. Semashko, proved to be a man of extraordinary mental power and tact and soon justified Lenin's choice of him as the head of the State Department of Health. He gradually gained the respect and the loyal cooperation of a large proportion of the medical men in the carry-

STATUE OF ALEXANDER IN LENINGRAD

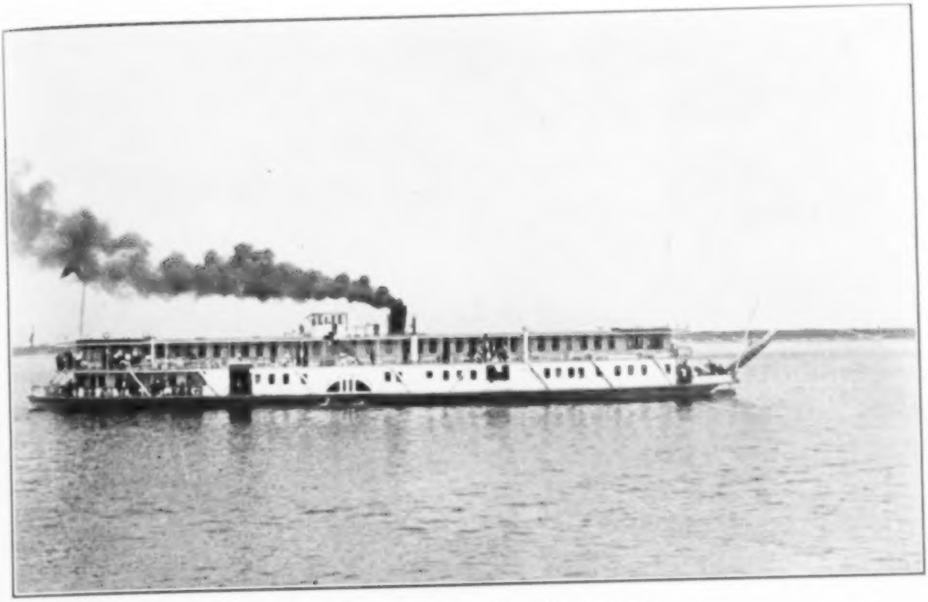
HOUSE OF REST
FOR WORKERS IN LENINGRAD.

ing out of his plans. As a member of the cabinet he was responsible for everything connected with the people's health and it was his duty to set up regulations promoting it. It was no small task to develop all the departments and bureaus that were necessary for curative medicine, for preventive medicine, for the teaching of medicine and for medical research. But, by virtue of his excellent ideas of organization and his ability to choose competent subordinates, he achieved a remarkable success and is generally looked upon as one of the most important of the real builders of the New Russia. He continued to be commissar of health for many years, but recently has given up, I was told, that post to undertake the supervision of the health stations of various sorts in the Crimea and on the Black Sea.

Medical Education in Russia: In order to supply rapidly a greatly increased number of practicing physicians, it was found necessary to make changes in medical education. By 1931, the number of physicians in Russia had been increased to 37,500, and it is expected by the end of 1933 to add 44,500 more so as to have then some 82,000 practitioners. Formerly, any student who desired to do so could engage in the study of medicine; now the students are especially selected; they are drawn chiefly from the families of the industrial workers and the peasants. This has necessitated special methods of preparation of the students for the study of medicine in the so-called "workers' faculties" and the teaching in these faculties, as well as in the medical schools themselves, has been made eminently practical at the expense of much theoretical instruction formerly given. New students enter the medical schools at two different dates each year. The course of instruction has been lengthened to ten months. The teaching is in relatively small groups, by the methods of the seminar or of the colloquium.

CROWD OF PEASANTS BOARDING A VOLGA STEAMER

Each medical faculty is divided into three parts, (1) a curative-prophylactic

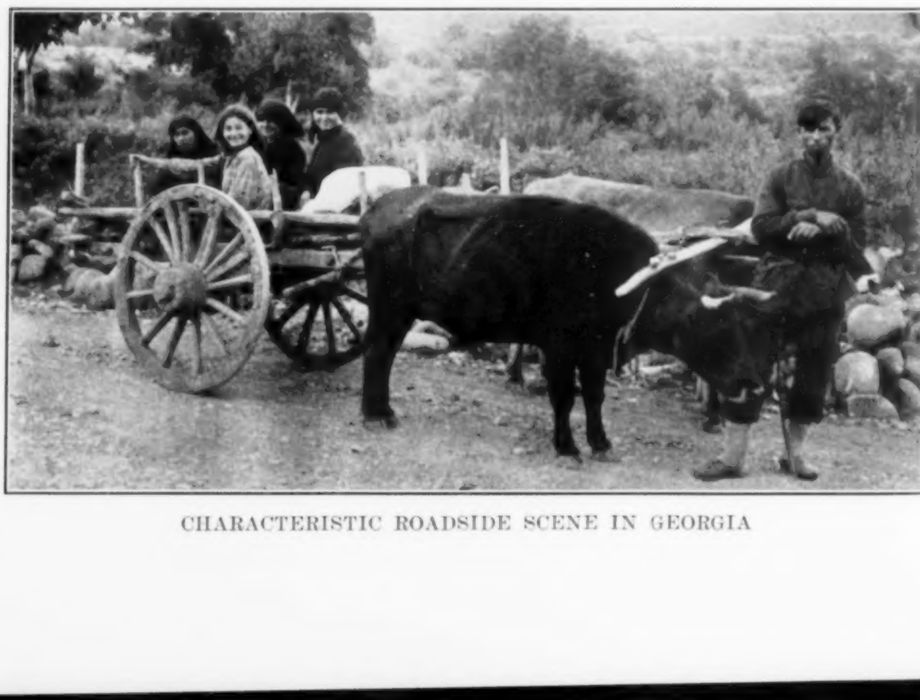


PASSENGER BOAT ON THE VOLGA

OIL BARGE ON THE VOLGA

INTOURIST BUS FOR THE GEORGIAN MILITARY PASS

faculty for the preparation of internists, surgeons and dentists; (2) a hygienic-prophylactic faculty for the preparation of public health officials, epidemiologists, food hygienists, etc.; and (3) a faculty for maternal and child welfare for training obstetricians and pediatricians. A medical student is, therefore, required to specialize almost from the beginning and he graduates as a specialist, rather than as an all-round doctor. There are more women medical students than men. In addition to the regular medical studies, students must have economic and military training, must study sociology and must take courses in dialectic materialism. The medical schools have been placed under the Department of Health



CHARACTERISTIC ROADSIDE SCENE IN GEORGIA

rather than under the Department of Education and thus are to be regarded now as technical schools rather than as university departments, though some of the medical schools are still under the aegis of the university.

The students, during their course, are taken into factories to study the sanitary conditions there, into the public schools to examine the conditions under which pupils work, and into the overcrowded homes of the masses to see where the hygienic defects lie. Thus, the medical schools lay great stress upon the social service point of view and upon a knowledge of the methods of preventing disease as well as upon that for treatment of disease. Similar efforts have been made to increase the number of women who study nursing and to improve their training.

The Practice of Medicine and Hygiene in Soviet Russia: While we were in Moscow we had the privilege of interviews with Professor Petrov, who is at the head of the Society for Cultural Relations with Foreign Countries, and with Dr. Oettinger, who represented the Central Department of Health. In addition, I had several talks with Professor Roman Luria, of Moscow, interviewed the head of the Woman's Clinic and the head of the Dietetic Institute in Leningrad, and talked with Professor Buchstab, the head of the Heart Clinic in Odessa, as well as with several of the research workers in various institutes of investigation. I also had a long interview with Professor Kairpinsky, the famous polar geographer, who, though over eighty years of age, is still the president of the Academy of Sciences in Leningrad.

PARADE ON DEFENSE DAY IN ROSTOV

In Russia, disease is no longer a private and personal matter. Since every inhabitant is a social and economic unit, disease is looked upon as harmful to the State, and restoration of the sick to health, the prevention of disease and the cultivation of positive health are regarded as State responsibilities. In

other words, Soviet Russia is witnessing, for the first time, the efforts of a thorough-going State medicine.

Not that private practice has been entirely abolished in Soviet Russia, for though every physician is required to work six hours daily for the State, he may, after that work has been done, treat private patients and be paid for such treatment if any desire him. It has not yet been possible fully to realize the ideal of making competent medical care accessible and free to all in the institutions organized by the State, and it is because of the delay due to insufficient personnel that the doctors still have some private practice. It is believed, however, that private practice is doomed ultimately to be wiped out as the numbers of physicians increase and as State institutions are multiplied.

The Central Department of Health, at the beginning, gave most attention to the control of epidemics, to maternal and infant welfare, to campaigns against tuberculosis and the venereal diseases, to the treatment of drug addiction, to the lessening of the abuse of alcohol and to the organization of State dispensatories and prophylactoria.

On account of the doctors graduating as specialists, it became necessary to organize them into groups in "unitary dispensaries," each such dispensary serving a district of say 30,000 people with approximately 1,000 daily visits from patients. At a dispensary, every person of the district must report for examination, whether he be sick or well, and he is studied, though I fear rather superficially as yet, by a group method of diagnosis, the results of the study being placed in the worker's "Sanitary Diary," a booklet that each visitor must present on his periodic returns to the dispensary. The social factors of disease and the collective measures for the prevention of disease receive the great-

ADVICE FROM LENIN

FORM OF PROPAGANDA ON THE END OF A FACTORY BUILDING IN STALINGRAD, "WITHOUT THE BOOK NO KNOWLEDGE; WITHOUT KNOWLEDGE NO COMMUNISM—LENIN."

CAMEL, THE SYMBOL OF LAZINESS

PLACED BEFORE THE FACTORY UNIT THAT FAILED TO COMPLETE ITS QUOTA OF WORK.

est stress. The conditions of the different occupations are carefully studied and the living conditions of the people in their homes are investigated with the object of instituting suitable preventive methods.

A great variety of forms of propaganda are made use of for the education of the masses in health measures. There are many public lectures, many articles in the newspapers, many radio talks, many moving pictures, a large series of colored artistic medical posters, many health museums and traveling exhibits—all of which are directed toward the instruction of the people in the causes of disease, in the ways of avoiding these causes, and in the modes of life best suited for the maintenance of positive health.

The authorities in Soviet Russia have introduced certain institutions that might well be imitated in other countries. Thus, undernourished children are sent to the so-called "forest schools," where they live for two or three months or longer under ideal health conditions, gain weight and are taught how to eat and how to live before being returned to the ordinary schools. Persons predisposed to tuberculosis or suffering from incipient tuberculosis and yet capable of some work are cared for in "day sanatoria" or "night sanatoria," close to the places in which they work, until they are believed to be in condition to live ordinary lives outside. In connection with the larger factories where one or more meals may be supplied during working hours, factory diet kitchens prepare four or five different kinds of meals for workers who have been found to have gastric hyperacidity, gastric anacidity, constipation, obesity or undernutrition. In one of the dietetic insti-

AN UZBEK

A FELLOW TRAVELER ON THE BLACK SEA BOAT.

ONE OF THE MEDICAL CLINICS IN MOSCOW

PART OF THE HEART CLINIC OF PROFESSOR BUCHSTAB IN ODESSA

tutes devoted to the study of food needs of the workers, I was given two meals, one for hyperacidity and one for anacidity, and ate both of them!

Venereal diseases were formerly very prevalent in Russia and are still widespread, though the Department of Health is making a vigorous campaign against them. An attempt is being made to reduce the number of prostitutes, and through the Workers' Clubs and the Sailors' Clubs many healthful opportunities for companionship, for games and for interesting studies are offered so as to reduce the temptation for seeking the companionship of prostitutes. The ease of marriage and of divorce and the free circulation of information regarding birth control are also said to be effective antidotes to prostitution.

Every child born in Russia, whether in or out of wedlock, is legitimized as the handicap of "illegitimacy" is considered to be unfair to any child. Moreover, up to two and a half months of pregnancy, a woman who does not desire the child may have an abortion done legally in a gynecological clinic, provided a committee of three members, including a physician and a social worker, approves. At the Woman's Clinic in Leningrad I saw two such abortions performed by two of the women assistants of Professor Podsoroff. One of these abortions was done under an anesthetic, the other without it. When I asked why these abortions had been legalized, I was told that the women otherwise would have them done by unskilled quacks and that the mortality among women thus treated had been very great; since the legalization of the abortions, the women apply to the gynecological clinics where the operations are performed skilfully, aseptically, and with almost no mortality. At the woman's clinic I visited, I was told that from ten to fifteen such abortions for "social reasons" are done every morning.

PROFESSOR ROMAN LURIA

OF THE MEDICAL CLINIC (FIRST FROM THE LEFT) AND THE STAFF OF THE RESEARCH INSTITUTE OF BIOLOGY AND MEDICINE, MOSCOW.

Much attention is paid in Russia to physical methods of therapy. This was very obvious at the Heart Clinic in Odessa, where Professor Buchstab, in addition to ordinary wards, has a large

FORMER PRIVATE VILLA

BEING CONVERTED INTO A SANITARIUM. SERVED AS LODGING FOR OUR PARTY IN SOCHI.

institute of hydrotherapy, provision for mechano-therapy of all kinds, and a large park connected with the clinic for open air and rest treatment and for graduated exercises.

The mineral water resources of Russia are being developed and spa treatment is becoming ever more popular. We visited the sulphur springs at Motesta (near Sochi) where many seemed to have great faith in the efficacy of both the external and internal use of the sulphuretted water.

All along the Black Sea and in the Crimea, the confiscated palaces and villas of the rich have been converted into vacation places and convalescent homes for the workers.

Research Institutes and Medical Publications in Soviet Russia: The number of institutes of research has been markedly increased in the larger centers since the advent of the Soviet régime. It has been possible, too, to retain as the heads of some of these institutes important scientists of the old régime, many of whom have not been sympathetic with the Revolution. There is a tendency, however, to place at the heads of the newer institutions, as rapidly as possible, young scientific workers who are socially and politically in tune with the present authorities. In every scientific institute, in addition to the scientific director, there is a Red director who controls the budgets and approves the appointments made.

The workers in the scientific institutes are informed that the old slogan of "science for science' sake" must be replaced by the slogan "science for practical application." Moreover, the doctrine that science should be combined with political economy and with world history into a unitary view-point, namely, that of dialectic materialism, is promulgated.

Though religion is still to a certain extent tolerated in Russia, religious organizations are not permitted to do social service work, charity medical work, or anything of the sort. Many of the

churches have been turned into anti-religious museums or into workers' clubs. Even foreign scientists invited to give medical lectures in Russia are criticized if they give expression to doctrines that are in conflict with dialectic materialism. Thus, the distinguished German pathologist, Aschoff, who was invited to lecture on pathology, was, I was told, much criticized because of his vitalistic views in pathology; as one man put it, "We do not want God smuggled into Russia in the form of vitalism." One native professor who had made important discoveries in histology and physiology but who had religious tendencies was transferred, I heard, from the post he held to another "in which he could do no harm." Still, on the whole, I was impressed with the fact that the Soviet authorities desire to foster and encourage medical research, and I could not help but have real admiration for the scientific workers in Russia who are endeavoring to hold the torch aloft despite the difficulties encountered.

It is reported that there are about 120 medical journals in Russia, this number including those published in languages other than Russian in the several autonomous Soviet Republics. The results of the more important scientific researches are, however, apparently published still abroad; formerly they went to French journals, but now, owing to the political situation, the German archives are more popular.

On our return from Soviet Russia, we were very glad that we had made the trip, and can recommend it to all who are interested in observing for themselves the conditions under which a novel social and economic experiment is being undertaken.

We are of the opinion that it would be wise for the United States to give diplomatic recognition to Soviet Russia, since this does not mean approval of its social or economic system but would favor the revival of trade relations and these in turn would tend to minimize the dangers of friction between the two countries.

SMOLNY INSTITUTE IN LENINGRAD

WHERE LENIN AND HIS WIFE LIVED DURING THE REVOLUTION.

SEBASTOPOL ON THE BLACK SEA (CRIMEA)

TYPICAL WHARF SCENE ON THE BLACK SEA

CONDITIONS IN SOVIET RUSSIA

Following is a list of selected references which will be of interest in connection with the foregoing article:

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RESEARCH AND INDUSTRY

By Dr. WILLIS R. WHITNEY
DIRECTOR, RESEARCH LABORATORY, GENERAL ELECTRIC COMPANY

In science, the mathematicians are now in the saddle. It is no longer necessary that a thing should exist in a form suitable for our imagination. If we know mathematical equations, we may proceed systematically to the utility, trusting that the understanding will advance with later familiarity. Most of our basic facts are quite beyond pictorial analogy. For example, the fundamental mechanics of light, of heredity, of thinking, of destruction and of creation are being left for the millennium. Meanwhile, the pure mathematician is directing our groping steps and suggesting many experiments. I name some number. Someone adds to it. Someone else multiplies it by something, and someone may subtract something from it. Let us say the result is number 49. So far that is nothing but a number. But multiplied by the right idea, it becomes perhaps a market price, your age, the year of the California gold rush, the area of some strip of land, or the size of a suit of clothes. You know at once that its names may be infinite. You were taught not to add numbers of different things, like horses and wagons, but you may do so, and you may multiply numbers by anything if you are so minded.

Let us, then, observe the wonderful complexities which are multiplying in the electro-magnetic field, where infinite possibilities in the radiations, or rays, promise countless new technical and social changes. I shall illustrate what I mean by the use of simple units, though I do need about all the numbers.

No one cares particularly what unit was used in labeling his radio dial, providing the numbers are useful. So I select corresponding and reasonably correct numbers without full explanation of the unit—call it a ten thousandth of one Ångstrom, or four tenths of a trillionth of an inch. But while the numbers on your dial may extend from 500 to 1,500, my new numbers, covering all conceivable rays, extend from unity to infinity. Moreover, the same peculiar unexpectedness of service and message appears throughout the whole series, just as is found in the narrow range of the parlor radio set. In other words, within a little group of numbers on a radio dial we find utility or advertising, music or pictures, and messages of all sorts. Moreover, if we stick to a single number we may get all sorts of information in time, and all the other numbers may treat us similarly. Even in the narrow range of radio, the possibilities are enormous, and it is a very young product. But contemplate for a moment what may be the possibilities between number one and infinity.

For analogy, consider bells. All their messages radiate through air (but not empty space) at 1,100 feet a second, regardless of the size of the bell. The utility or message of the tiniest bell on some kitten's neck is distinct from that of the fire alarm or church bells, but from the smallest to the largest of bells, the range is really very small. Representative numbers based on weight of the bells, frequency of the vibrations or wave-length of the air waves, would hardly extend from unity to a million. But the numbers applicable to electromagnetic possibilities, on the other hand, extend from one, clear through the quintillions of ordinary alternating current, on to infinity. Thus I have numbered from one to infinity all the

different forms of available energy which radiate at the velocity of 186,000 miles per second—what I call practically infinitely fast, for nothing will ever go faster. My numbers are not quite individualistic, but are like population statistics. For example, the inhabitants of one farm may be roughly between one and ten, of villages from 10 to 1,000, cities from 10,000 to ten million, etc. But behind both systems lies a certain possible effect of each individual. Number 3 on the farm may be a potential president, number 999 in a village may do his service in jail.

So what I am numbering from one to infinity are the different electrical possibilities. I have chosen the numbers to correspond to what I will call a kind of length, just as the men in a city might be consecutively numbered as to height, weight or skill. There may be no wavelengths to rays, but we can still use the numbers, and the main point is that the scale is infinite and each unit has many possibilities.

It was only a few years ago that this completeness of our electro-magnetic numbers was first recognized, and now the greatest sport in physical science or in electricity is experiencing the surprises of new numbers. New groups of numbers, like safe-combinations, turn out to be combinations for unlocking unexpected utilities. One may say that every novel combination so far has opened some surprise which only subsequent research has deciphered. For example, after we first saw our bones through our bodies it took years of work to learn the numbers we had used. The safe, so to speak, was opened by accident, and no one at the time even suspected that the combination consisted of electro-magnetic numbers rather than dynamite.

Cosmic rays at present fit the lowest numbers, which I start at unity. The numbers of these radiations, which Dr. Millikan is studying, range from 1 to 10, and suggest some ultra-microscopic electro-magnetic sender, and consequently complete wireless station of inconceivably short wave-length, like some bell which is far too small to be seen by any microscope. The messages in this numerical range seem to be telling us about the formation of matter, the birth of stuff, the click of energy.

There is a discussion going on among astronomers and physicists as to whether the universe is really running down, or just running around. Men had thought it was running down. Everything that we can do to keep the Humpty Dumpty universe on the wall really seems to lower the wall a little. We apparently can not do anything and still leave the outfit quite as well off in energy as it was before. Moreover, we know now that some of our elements are just naturally falling apart and decaying in a way that has seemed to have no reconstructive counterpart, and there appears no way of even delaying the decay. But out of cosmic space somewhere there are coming rays of numbers one to ten, and if our ideas of these little numbers are correct, they may be a kind of space-reverberation of riveting of the constructional mechanics by which our smallest atoms are being built from nothing. This nothing has emphasis on the final syllable, for they seem built of energy and not things. And so our first electro-magnetic numbers represent rays that will penetrate many feet of the densest substances and still record themselves on little electrical counters just like the devices used for handling the much larger numbers.

Next to the cosmic numbers 1–10 come those of 10 to 1,000. This group represents the gamma-rays of radium and similar messages from the inside of heavy atoms. They tell us of the gradual destruction of matter under local conditions, and the history of our ele-

ments. That is, we have thereby learned the intermediate ancestors of matter. These rays have the power of making air conducting for electricity, just as do the cosmic rays and adjacent higher so-called x-rays. Here again each individual number will some day prove to carry a special message, and, as in other cases, it will probably be found that many different services can be performed by each one, just as each apparently tells us now of some greater or lesser earthquake in atoms.

The common x-rays are numbered from 10,000 to 100,000. Nothing would have seemed more unlikely a few years ago than that this invisible light would usefully shine through our bodies as well as through bodies of wood and iron. It took several years to discover that these rays were also in the electro-magnetic series. Still newer messages are now being received from them constantly. Without referring to therapeutic uses of both radium and x-rays, we should note that pollen, seed and plant, sperm, egg-cell and animal are all affected by this group of numbers. Recent biological work seems to promise new types or forms of plant and animal through action of these rays upon the mechanics of plant and animal heredity. They seem to affect all living things just at the time when these have not completely determined just what they want to become.

Just as unbelievable service is coming from the numbers 1 million to 35 million. This has been called the ultra-violet range. They are invisible in the ordinary sense, but living nature seems to be particularly sensitive to this group. Here, too, the messages are quite unforeseen, and are daily being augmented. In young animals, certain blood deficiencies account for lack of bone-growth. This has been shown to be due to food defects, lack of light, or both. One of the components of food which is necessary for normal growth has been named vitamin D, and it has been shown that this is producible by our numbers one million to thirty million from materials which contain certain organic compounds part way up the scale towards this vitamin. Here, as elsewhere, it is clear that numbers very nearly equal to one another do not serve this purpose equally well, and are in some cases even antagonistic—again a proof that these individuals are highly individualistic. Recent work on the radiation of food by a moderate ultra-violet range has shown the need of selecting within that range certain numbers and omitting and actually cutting out others. Perhaps as remarkable as anything in this group of rays is that they may be applied directly to the diseased animal and cause the same bone growth and recovery of normal blood composition as though the product of the action of the rays on its foods were eaten. It is interesting that numbers in the thousands of the x-ray group are used to photograph and thus demonstrate the changes as they are being brought about in rhachitic animals by exposure to the numbers in the millions. Both services are fairly modern technical advances. Both were rather unpredictable and quite specifically individualistic and valuable.

This series of electro-magnetic food messages fits wonderfully well into other knowledge of foods, where already five or six essential vitamins are recognized. On the other hand, this work also fits the reactions of simple chemistry without reference to life reactions. For example, the production of ozone from oxygen is brought about by numbers near 20 millions, and the reverse production of oxygen from ozone by numbers about 60 millions. Many organic chemical reactions are brought about by numbers between 20 million and 24 million.

Such discoveries, now firmly established, are suggesting countless other experiments, and thus probably all growing matter and many inorganic processes will be investigated as to the effects of rays of particular numbers.

Our electro-magnetic numbers include ordinary "light" as well as "long wave radio," so that we might expect to find some new choice of words for explaining ordinary light. How is it a wave and how a group of darts? Does it arrive without coming, or should it be accepted as an event without fixed explanation? On my number scale, visible light extends from 35 millions to 76 millions. It is hopeless to outline the countless utilities and messages of this particular range, but I ought to point out that even here there are also infinite shades and colors, and each number tells us something new. The actual composition of the celestial universe has been broadcast to us in thousands of these spectral numbers, and many have only recently been translated into words. (The number 58,760,000, called the helium line, told of helium in the sun long before the stuff that fills Zeppelins was discovered on earth.) They tell us of the breaking down of all our chemical elements in sun and stars under conditions of temperature and pressure which are quite beyond our comprehension.

Beyond the light rays are the heat rays, 80 million to ten billion. The penetrating power of some of these through living tissues has been studied because it may be desirable and possible locally to raise internal body temperature higher than by the older methods of direct thermal contact.

From one hundred billion to a hundred trillion there is a great range called the Hertzian. These waves are too long to be felt as we feel heat, and too short to be used in radio. No one can tell what uses may be found for them, but watch out!

Then come the longer waves which approach those of short wave radio. These are numbers from a hundred trillion to a thousand trillion, and one selected part has interested me because of its fever production, as I will describe it later.

The short wave radio corresponds to numbers around ten thousand trillion, and these are being used more and more for around-the-world broadcasting, because, being shorter than those used earlier, they are reflected from the conducting layers at the top of our atmosphere better than the longer wavelengths which tended more to go directly out into interstellar space.

The ordinary broadcasting range involves the numbers from 20 to 60 thousand trillion. I can not see why there may not be sufficient units in this range to allow for new applications to needs quite unthought of as yet.

If we continue our numbers upward, we finally reach the old familiar alternating currents, for their waves at say 500 cycles and 60 cycles are similar to our most familiar light except that the numbers are respectively sixty and five hundred million trillion. All these electro-magnetic waves, from one upward, seem to travel at what I have called equal and infinite velocity. I just say that. Ordinarily we attach the number 186,000 miles per second to this rate. But the mathematicians show us that it is faster than anything (however small) could be made to move (no matter how hard it was pushed), so it seems practically infinite and fits better my crude idea of what electro-magnetic speed ought to be. Moreover, the thing pushed, in our case, if it really goes through space at all (as distinct from sitting on the borders) is simply called energy.

It may be of interest to tell briefly about a few tests we have made, using radio energy in fields apparently quite

remote from technical affairs. They owe their origin almost entirely to the fact that new kinds of radio tubes were being developed faster than I could understand them, and so I decided to play, in spare time, with a few so-called tube circuits, for my personal orientation. It is also more fun telling about my own personal researches than of the work of other men of the laboratory. They should tell their own stories.

"Research and Industry" is the title of this article, but the thought behind most of it is that some research may be quite vagarious and capricious. When carried out in large industries many byways are fortuitously opened and byproducts investigated which evidently could not be intelligently planned before or at their beginning. In general they do not warrant vigorous attack until some comprehensive or promising stage has been more or less accidentally attained. The start of this particular research on radio was quite unrelated to industry.

The first experiment was an attempt to grow, by radio catalysis, a gall on a plant on my farm. I was just letting my mind wander, perhaps, but I had long been interested in the similarities between plants and animals. Both grow from fertilized cells, both are connected colonies of countless individual cells, both have circulation systems, and even the chlorophyl of plants reminds one of the protoplasm of animal life. They developed from the same original aqueous life, and both retain circulating salt solutions called sap, plasma or blood. I had read about the similarity between animal and plant repairs, scar tissues and tumors. I was surprised to see how many different plant tumors and galls there are. Many of them are due primarily to the deposit of an insect's egg into the living part of the plant. The plant produces a maternity hospital for the insect. There was a variety of explanation of this abnormal plant growth. It has been attributed to formic acid or other chemical agent supposedly introduced by the insect which planted the egg. Then it was credited to certain bacteria which infected the plant when the egg was laid. If it is an evolution to provide a home for a growing insect it seems worth while to attribute it to some factor which is a necessary part of the growing insect itself. I still do not know the cause. A simple case is the goldenrod gall. There are several types of these, but one is a spherical growth nearly an inch in diameter which quite commonly occurs about three quarters the distance up the stem of the American goldenrod. I had played with this for years, and had noticed that there was another goldenrod gall, not spherical, but cylindrical, several times as long as it was wide. The grub or larva which occupies such a gall is nearly spherical in the spherical gall, and is a long worm in the cylindrical gall. So it seemed possible that the galls were just places where the rate of plant-growth was raised above normal by the slightly elevated temperature of the egg and larva. It is no stretch of imagination to think of insects as warm, and even in living eggs energy is consumed, so heat is generated. Such tumors, or galls, are like animal tumors; they are proliferations, or excessive growth of normal tissue, and the cells are characteristic of that part of the plant or animal in which they grow. This is well known.

Every chemist knows that, in general, rates of chemical processes rise between two and three-fold for each ten degrees Centigrade rise of temperature, and this might mean a possible very appreciable gain in mass for that part of the growing plant which was heated above its environment. So I thought that if I could put the hot greenhouse inside the plant instead of the reverse, I might grow a tumor there.

In the very high-frequency radio-field we had a device for heating certain types of resistance at remote distances. A whole plant could be warmed internally by submitting it to the electromagnetic field, but the degree of heating varies also with the nature of the thing to be heated. I realized that an insect's egg or larva could not be easily imitated, but I found that a very minute piece of steel, the tip of a very fine needle, could be inductively warmed enough to slowly melt its way through wax even when the power was low and the coils or antenna were at some distance. So I concluded that this heat or power could not injure the plant. The tiny needle-points (my warm eggs) I inserted into the stems of young, potted goldenrods, and applied the radio energy for a summer, and then repeated it the next summer. But except for a gall which grew on one of the plants from an egg which, without my knowledge, was already in the stem, I never succeeded in producing a plant tumor. I have not given it up, but I have learned a lot about plants without learning how they do determine new growth. Probably they, like the trees, grow only in a sort of shell surrounding their past growth, the cambium about the idle wood. The little gall fly knows better where to put her eggs than I do. My steel eggs either remained dormant just where I put them (while the stem placidly extended above them) or, when I had put the needle-point right into the growing tip, it was later found at the top of some young leaf. I could not grow a tumor. And I could not give up. It seemed certain that extra heat inside a plant should speed up local growth, just as putting a whole plant in a warm place forces all the parts. So, though it may be foolish to admit it, I tried again, with the same idea applied to growing onions and to small trees, but without getting the particular narrow-minded result I sought. We did learn, incidentally, as often happens, that it was easy to kill the grub in the galls by application of the radio energy, and we knew that this was due to the grubs being overheated internally. This led to experiments on fruit-flies, because they are the test-tubes of the biologist. We found that when ice cold air was blown through a tube of these flies they immediately hibernated and seemed dead. If, now, we applied the radio field while the air and all the surroundings were still at ice temperature, the flies became lively and flew about, and with a little more external radio energy they would die from internal overheating. This was destructive, but not productive.

Such experiments led to others on rats and dogs, for here we could measure the induced temperatures and follow the effects. At about this time, some of the engineers thought they felt the energy in their bodies, their knees heated when near a large generator, and this was investigated. It was found that a man near a large outfit of unusually short wave-length rose in blood temperature a degree or more.

In our experiments we had first made imitation animals out of gelatine. Instead of sweetening our jellies, we used common salts and studied those concentrations corresponding to animal blood. In this way we found that the heating effect varied with the salt concentration, and that with any particular concentration like normal blood, we got the quickest heating when a certain wave-length (number approximately ten thousand trillion) was used. Later we learned that, given such data as conductivity and dimensions, it is possible to calculate what electrical hook-up will best serve a given purpose.

It was not at all clear, even when we knew that the heating took place within the body fluids, that it was harmless,

and for that reason our jelly rats were followed by real rats. The early work with little numbers like ten thousand (or x-rays) had shown one of the most remarkable known biological effects, and we had repeated it on insects. Rays in the range ten to one hundred thousand do something destructive to living matter which may not disclose itself for years, but, by increasing the dose, the effects may be brought out quickly. So with x-rays, we had treated fruit-flies in lots of a hundred to different doses while they were in closed wooden boxes, and we found that while homeopathic doses did no harm, larger doses insured a regular subsequent time for death, an exact death-expectancy. For example, after a certain dose, the flies would live for ten days, but die in twelve. Two half doses were equal to one full dose, etc. We found no such effect with number ten thousand trillion, however. We found, instead, that rats liked a certain amount of this radio heat. So we made a long glass house, in one end of which the radio field could warm the rat without heating the house, and in another part there was an ice-cooled box. Thus the rats could choose their preferred temperature. They soon moved their cotton bed into the electro-magnetic field. Then we gradually, from day to day, increased the intensity of the field, so they became warmer and warmer. No one knows how far we might have gone, but one day one of the rats came hurriedly out of his warm bed leaving his tail in the cotton. The tail proved to be entirely dried out. The rat was unhurt except in appearance, and ate out of my hand at once. Now I am not advocating this as a painless surgical process, but will the day ever come when we may be warmed internally in unheated houses by some external radio field? It might be useless to heat our houses with all their contents including the air, if we could get along by internally heating ourselves. Our early ancestors did it without radio. They carried enough heat with them, and their rooms were not heated in their absence. If we carry the body temperature higher than about 98° F. we say we have a fever. We found first with rats that fevers were harmless unless above 106, and rats have withstood 111°. Dogs can not usually recover after being exhausted by several hours of electrical fever of, say, 107°, but all animals stand indefinitely a few degrees of fever. It is a wonderful way of reducing weight, for the animal peacefully perspires his fat away. This is not advertising for reducing.

One day a veterinary brought us a little white Boston bull terrier which he said was going to die of dermidectic mange. It couldn't do any harm for us to experiment on her, and we accepted her as a gift and called her Lydia. Enclosed in her little wooden kennel, she was subjected to an hour's electric fever daily. It is a long story full of human interest, but the dog got well. The human interest was so great that Lydia also got all the medicine we could think of, in addition to the fevers. She was put on a strict diet daytimes, and accompanied the watchman on his rounds at night, so it may have been a faith cure. It was clear, however, that repeated electrical fevers do not hurt small white bull dogs.

All this in turn led to our finding that human fevers may not be all bad, but some are probably beneficial, and we learned about the work of Dr. Wagner-Jauregg, of Vienna, who had cured cases of advancing paresis by producing at will fevers of malaria in the patient. There was only one thing to do then. We made a few devices and lent them to institutions where it seemed probable that the indicated studies could be well made.

It is not new to heat the body by external means and to produce fevers thereby. It has been done by hot water baths, but the patients usually have to be tied down before they will submit to it. It is also not new to heat a human being by strapping electrodes to him and applying alternating current of high frequency, but it is new to heat the individual by radiations or electromagnetic energy emanating from an antenna. For uniformity, the present method is to let the patient lie on a cot with antennae plates above and below, but not touching him. It is at present being studied largely as a substitute for the purposeful malarial fever infection which is the wonderful service Wagner-Jauregg rendered after painstaking studies over many years. I do not profess to know the action, but the guiding thought was this: In such diseases as paresis there is a blood parasite whose ultimate goal seems to be the brain cells of the host. It gets there effectively only after a long siege in the blood stream and spinal fluid, but the mind is finally affected, and until Wagner-Jauregg's work, I believe that there was no cure. He showed a way, through introducing fevers, to save at least some of the afflicted. It seemed a natural thing to assume that the fevers finally made the parasite give up in disgust, not being able to stand the heat. This general principle must be tried on various human and animal troubles. There are now several groups of competent American doctors and research men in well equipped institutions who are making these studies, and it seems from their reports that there is hope for service from this particular radiation number, ten thousand trillion.

COSMIC DISTURBANCES OF THE EARTH'S MAGNETIC FIELD AND THEIR INFLUENCE UPON RADIO COMMUNICATION[1]

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Purpose and Scope

It is hoped to show this evening that there are correlations, found by observation, to exist between (*a*) the strength of long-distance received radio signals, (*b*) changes in the apparent height of the ionized layers of the upper atmosphere, (*c*) changes in the Earth's magnetic field, and (*d*) disturbances on the surface of the Sun, as revealed by sunspots. Certain of these different phenomena are interconnected in recognized ways; but the reasons for the observed correlations between others are still mysterious. In order to solve these difficult cosmic problems, more numerous and more varied observations are needed, as to what is taking place in the upper atmosphere, and beyond. It appears, however, that by carefully studying the behavior of radio waves, directed experimentally skywards and received on the ground, after being reflected back from different elevations, it may be possible to throw light upon the nature and constitution of the otherwise inaccessible upper air.

The Ionized Layer or Layers in the Upper Atmosphere

In the early days of radio telegraphy, before the beginning of the twentieth century, it was supposed that when a simple radio impulse was started from a mast at a sending-station, a hemispherical electromagnetic wave was emitted from the mast as a center, like the upper half of a soap-bubble, expanding in all directions at the speed of light. The lower edge of this invisible hemisphere ran over the conducting surface of the ground or sea, in all directions, north, south, east and west, at the rate of 300,000 kilometers per second; while the top of the hemisphere shot upwards also at this speed. Only the lower edges of this wave, near the ground, could carry the impulse to receiving-stations. The electric energy in the upper portions of the hemisphere would be useless for communication. This was the then generally accepted doctrine of three-dimensional expansion of radio waves.

When the Marchese Marconi came to North America in the late fall of 1901, to see if radio signals could be received from England across the North Atlantic Ocean, he was able to report receiving groups of dot-impulses caught in Newfoundland by a kite-lifted conductor, as emitted from his sending-station in Cornwall. The amount of energy required to operate the receiver was greater than should have been obtainable from the emission in England upon the three-dimensional hypothesis, and it was necessary to invoke some suggestion for preventing the heavy loss of energy upwards during transmission. It had been shown by Sir J. J. Thomson that highly rarefied air was capable of conducting electricity better than sea water, so that it was reasonable to assume that at an elevation of nearly 100 kilometers, the air was sufficiently rarefied to act as a conductor under the ionizing influence of

[1] The second in a series of three lectures concerning the magnetic field of the Earth and its atmosphere, delivered at the Carnegie Institution of Washington, March 15, 1932.

powerful sunlight. It was known that the chemically active rays of the Sun, near the violet end of the spectrum, are able to ionize air, that is, to break up neutral gas atoms into electrically positive and negative constituents. The radio waves emitted from the sending-station would thus only expand hemispherically, until the ionized conducting-layer was reached, about 100 km above the station. Here they would be reflected back to the ground for repeated reflection upwards; so that the wave would then expand in two dimensions only, like a cart-wheel 100 km thick, the wave advancing radially, along the spokes.

This hypothesis of an ionized layer or layers in the upper air, prognosticated in 1902, was not verified experimentally until Breit and Tuve, at the Department of Terrestrial Magnetism of the Carnegie Institution, photographed in 1925 the arrival of radio echoes from the overhead ionized layer.[2]

Fig. 1, taken from a paper by Appleton,[3] represents diagrammatically a

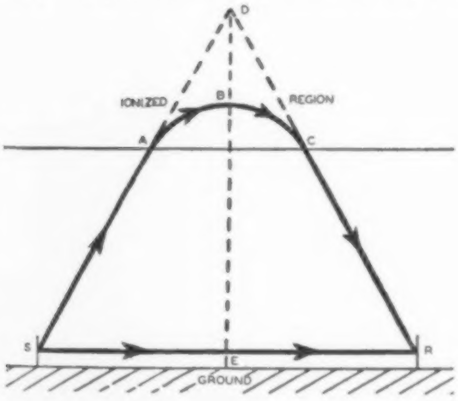

FIG. 1. DIAGRAM OF RAY-TRACK (AFTER APPLETON).

[2] G. Breit and M. A. Tuve, "A Test of the Existence of a Conducting Layer," *Phys. Rev.*, 28, 554–575, 1926.

[3] E. V. Appleton, "Some Notes on Wireless Methods of Investigating the Electrical Structure of the Upper Atmosphere," *Proc. Phys. Soc.*, 41, 43–59, 1928; 42, 321–339, 1930.

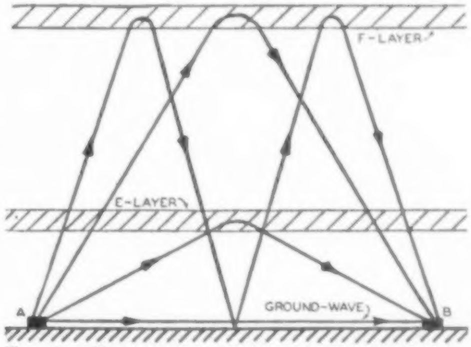

FIG. 2. VARIOUS PATHS BY WHICH PULSE MAY ARRIVE AT RECEIVING-STATION (AFTER GILLILAND AND KENRICK).

radio sending-station S and a receiving-station R, situated on the ground-level SER, say 150 km apart. An outgoing radio impulse, emitted at S, reaches R over the ground, following the direct horizontal ground-path SER. This is called the "ground-wave." At almost the same moment, an upwardly directed ray SA reaches the ionized region ABC, the lower boundary of which is probably not sharply defined. On entering the region, the ray is bent from the straight path BAD into the refraction-path ABC, so that emerging from the ionized layer at C, it reaches the receiver R by the downward line CR. The up and down ray $SABCR$ will take a little longer to reach R than the ground-wave, and will reveal itself as an echo-signal following behind the ground-signal. The observed time of delay will furnish a measure of the apparent height, or virtual height, ED, of simple virtual reflection. This virtual height is greater than the actual height of the lower boundary AC of the layer, and also greater than the height EB reached by the ray before being turned back.

Fig. 2, from a recent paper by Gilliland and Kenrick,[4] indicates two ionized

[4] T. R. Gilliland and G. W. Kenrick, "Preliminary Note on an Automatic Recorder Giving a Continuous Height-record of the Kennelly-Heaviside Layer," *Bur. Stan. J. Res.*, 7, 783–789, 1931.

layers, which Appleton has called the *E*- and *F*-layers, respectively. The *E*-layer is lower, and long radio waves tend to be reflected down to ground from it. Shorter waves can penetrate the *E*-layer, and may then be reflected down by the upper *F*-layer. The sending-station at *A* emits rays in all directions, including those along the ground. The ground-wave *AB* reaches the receiver at *B* by the direct route. A pulse is shown reflected from the lower layer *E*. There will be a certain short delay between the arrival at *B* of the ground-wave and the reflected *E*-wave. Then there is a wave shown which succeeds in passing through the *E*-layer twice, first upwards and then downwards, being reflected from the *F*-layer but not intercepted by the *E*-layer. This *F*-echo ray will have a greater delay than the *E*-echo. Finally, there is a pulse shown which is reflected from the *F*-layer to ground and then back from ground to sky, again reflected from the *F*-layer and reaching the receiver *B* after passing four times, in all, through the *E*-layer. In such a case, the photographic recorder at *B* would show one ground-pulse followed by three echoes, each of which has pursued a different path.

In some tests no echoes are found, and the ground-wave arrives alone. In others, one echo is found, while in yet

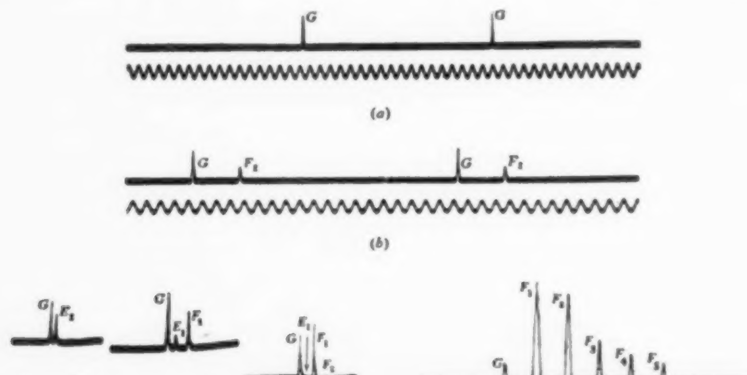

FIG. 3. DIFFERENT TYPES OF REFLECTION (AFTER APPLETON AND BUILDER).

FIG. 4. HEIGHT-RECORD SHOWING GRADUAL RISE OF LAYER FROM 241 TO 399 KM, AND TEMPORARY APPEARANCE OF OTHER LAYERS; RECORD RUNS FROM 5:30 P. M., JUNE 12, TO 2:15 A. M., JUNE 13, 1931, FOR FREQUENCY 4,045 KC; THE GROUND-TRACE APPEARS AT BOTTOM OF RECORD (AFTER GILLILAND AND KENRICK).

others there may be six or more. In Fig. 3, which is taken from Appleton and Builder's paper[5] of January, 1932, there are various records of echo-patterns, obtained near London at different times. Time measurements are furnished by the serrated lines below each record, the frequency being given as 1,110 cycles per second; so that the interval between successive serrations is roughly one millisecond (0.0009 sec). The record at (*a*) shows only two successive ground-waves *G*, *G*, emitted about one fiftieth of a second apart, no echoes appearing. At (*b*) there are two records, each showing a ground-wave followed by one echo F_1, attributed to the *F*-layer, and arriving about 4 milliseconds (0.004 sec) later. If the delay were just 0.004 second, it would correspond to an extra length in the echo-path of $300{,}000 \times 0.004 = 1{,}200$ km, or to a virtual layer-height of approximately 600 km. At (*c*1) there is a ground-wave *G*, followed after about one millisecond by a single echo E_1 assigned to the E-layer. This delay would correspond roughly to a virtual layer-height of 150 km. At (*c*2) there is a ground-wave *G*, a small echo E_1 of about one millisecond delay from an *E*-layer, and then a larger echo F_1 of about 3 milliseconds' delay from an *F*-layer at a virtual height of about 450 km. At (*c*3) there is one very small *E*-echo and two *F*-echoes F_1 and F_2. At (*d*) there is no *E*-echo visible; but there are no less than four *F*-echoes at sensibly regular intervals. Similar echo-patterns, rather more complex, are given at (*e*), (*f*) and (*g*).

[5] E. V. Appleton and G. Builder, "Wireless Echoes of Short Delay," *Proc. Phys. Soc.*, 44, 76–87, 1932.

Similar oscillographic records have been made at the Department of Terrestrial Magnetism, by Tuve, Hafstad and Dahl.

Very recently, it has been found possible to obtain continuous photographic records of the virtual heights of the ionized layer or layers, by means of a special apparatus[4] designed for that purpose at the Bureau of Standards, under the direction of Dellinger. Such a record, covering a period of nearly nine hours, is given in Fig. 4. The ground-signals, forming a continuous heavy line, appear at the bottom of the record. There are then two curved lines, more or less parallel, indicating series of reflections from two virtual heights. There are also transient records of intervening layer-reflections. As the virtual height increases, so does the elevation of the corresponding curve from the base of the diagram.

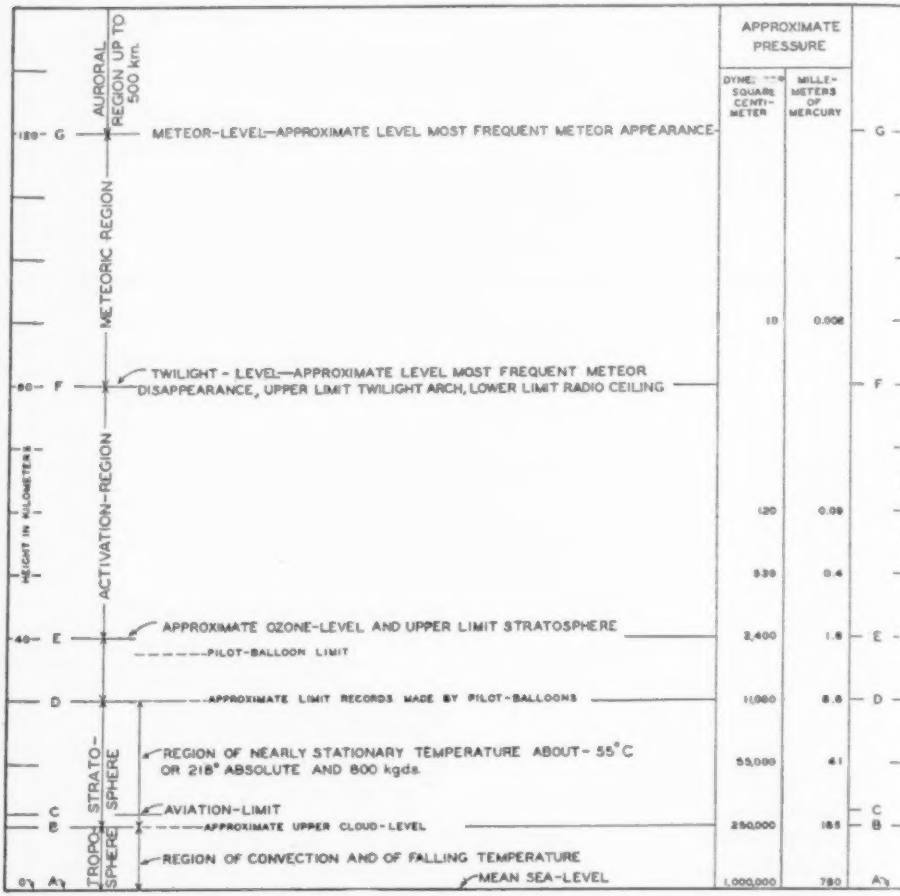

FIG. 5. OUTLINES OF ATMOSPHERIC REGIONS UP TO 120-KM ELEVATION (LEVELS B, E AND F ARE NOT FIXED, BUT ARE STATISTICAL AVERAGES VARYING WITH THE SEASON AND THE LATITUDE).

TROPOSPHERE, STRATOSPHERE, ACTIVATION, METEORIC AND AURORAL REGIONS OF THE ATMOSPHERE

A diagrammatic vertical section of the atmosphere, up to a height of 120 km, is given in Fig. 5, which has been prepared with the kind assistance of Professor Alexander McAdie, of the Blue Hill Meteorological Observatory. Here the bottom line *AA* represents mean sea-level. The level at *B*, 10 km up, gives the approximate upper limit level of clouds in the sky; while the 10-km layer *AB* is described as the *troposphere* or region above which the temperature ceases to fall and begins slightly to rise again. It will be understood that this dividing line between the troposphere and *stratosphere* varies with the latitude of the locality, season of the year and hour of the day, so that the elevation of 10 km is only a rough round number easily remembered. The other levels at *E*, *F* and *G* are likewise only averages.

At or near 12 km, *C* in the diagram, is the approximate limit of aviation height. At *D*, 30 km up, is the approximate limit of elevation from which rec-

ords have been secured by apparatus sent up on "pilot-balloons"; while at 37.5 km we have the limit of non-recording pilot-balloons.

At *EE,* 40 km elevation, we have the approximate upper limit of the stratosphere and the estimated "ozone-level." From *EE* to *FF,* we have an activation region in which ionization is supposed to develop actively during daylight hours. At *FF,* 80 km above the sea, is the twilight level. Near here is the upper limit of the twilight arch in the sky, the most frequent level of meteor disappearance, the lower level of the lower ionized layer or *E*-layer of Appleton's observations, and also the lower limit of auroral displays.

Between the 80-km and 120-km levels *FF* and *GG,* is the meteoric region, in which meteors are most abundantly visible. Above the meteor average appearance—level *GG,* extends the auroral region, and the region of upper ionization up to say 500 km. Above the 30-km level, however, from which direct records have been secured, information concerning the nature and constitution of the upper air is at present necessarily fragmentary and indirect.[6]

Correlation of Long-wave Transatlantic Radio Signal-strengths with Terrestrial-magnetic Fields, and with Sunspots

In Fig. 6 there is seen a plotted series of observations of monthly average radio signal-strengths over a period of seven years (1921–28), emitted by Lafayette station, and recorded (heavy line) at the Bureau of Standards in Washington, by Austin, and (dotted line) at the Meudon Observatory, near Paris, France. The Lafayette station is close to the Bay of Biscay shore, near Bordeaux, France, and its conditions of signal-emission are reported at regular intervals. It will be seen that there is good correlation between these curves, which rise and fall together. These 3 P. M. (Eastern Standard Time) signals are strongest each year in the winter and weakest in the summer months. The ratio of annual low to high is smaller at Meudon than at Washington, D. C. The direct path of transmission is entirely overland to Meudon, across France; while it is almost entirely over the sea, to Washington, across the Atlantic Ocean. Here the annual fluctuations may be partly cosmic, that is, produced by influences outside the Earth's surface, and partly terrestrial, or by influences at or within the Earth's surface; but the effects are similar in both series of observations.

Photographic records of the elements of the Earth's magnetic field, as obtained at Cheltenham, Maryland, have been maintained by the U. S. Coast and Geodetic Survey for many years, and a daily record of the strength of radio signals from several European long-wave radio stations has been maintained by Austin at the Bureau of Standards for 17 years. Austin's comparison between the magnetic activity in magnetic horizontal intensity and radio signal-intensity is presented in Fig. 7. It shows a fair degree of correlation. It is not yet

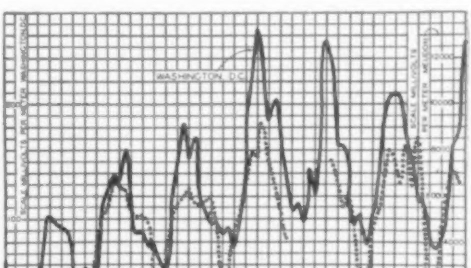

Fig. 6. Monthly average signal-intensity as received from Lafayette station (FYL at Washington and at Meudon, 3 P. M. (after Austin).

[6] Alexander McAdie, "Observations and Investigations Made at the Blue Hill Meteorological Observatory in 1929," Cambridge, 1930.

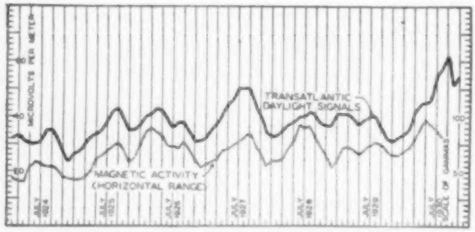

FIG. 7. CORRELATION BETWEEN MAGNETIC ACTIVITY AS INDICATED BY RANGE IN HORIZONTAL INTENSITY AT CHELTENHAM, MARYLAND, AND RECEPTION-INTENSITY OF TRANSATLANTIC DAYLIGHT SIGNALS (AFTER AUSTIN).

clear as to the nature of this correlation. It may be attributable in part to variation in the ionized layer, the radio ceiling over the Atlantic Ocean, or to cosmic influences not yet grasped. In this case, the radio signals were received from Europe in an east-west direction. A similar analysis by Austin for signals from Argentina, received over the Atlantic in a south-north direction, as given in Fig. 8, for the four years 1924–28, seems to show but little correlation; so that apparently the direction of transmission enters into the relation.

A set of curves appears in Fig. 9 for

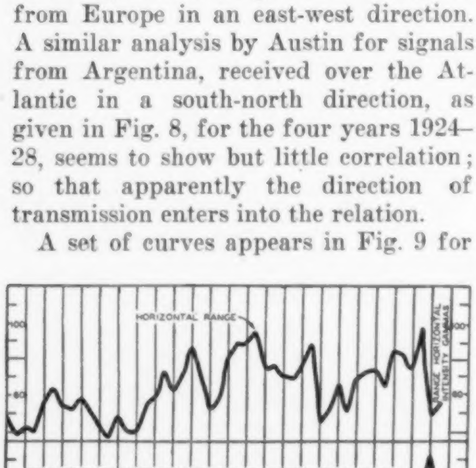

FIG. 8. CURVES OF MAGNETIC ACTIVITY AS INDICATED BY RANGE IN HORIZONTAL INTENSITY AT CHELTENHAM, MARYLAND, AND RADIO SIGNAL-STRENGTH FROM STATION MONTE GRANDE (LPZ) IN ARGENTINA, SHOWING LACK OF CORRELATION ON NORTH-SOUTH RECEPTION (AFTER AUSTIN).

three series of observations—(*a*) radio signal-intensity, averaged from several European stations, as measured at the Bureau of Standards, (*b*) sunspot-numbers and (*c*) the solar radiation-intensity as measured by the Smithsonian Institution, all for a period of three years. Here we have very distinct correlation between the three curves. Some interrelation exists between these solar variations and radio variations. Perhaps it is attributable to the conditions of the ionized layer.

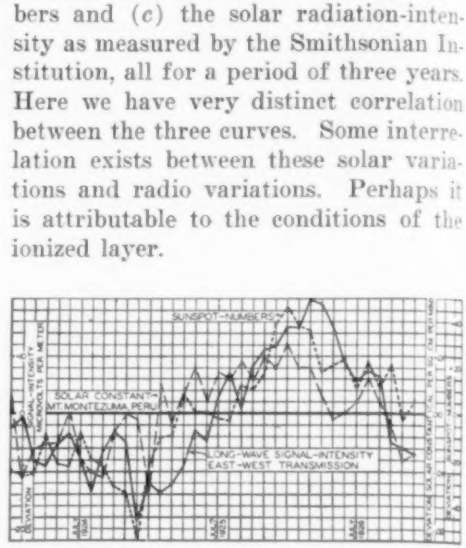

FIG. 9. CORRELATION BETWEEN SUNSPOT-NUMBERS, SOLAR RADIATION AND SIGNAL-INTENSITY AS RECEIVED AT WASHINGTON, 10 A. M. AND 3 P. M., FROM EUROPEAN STATIONS DURING JANUARY, 1924, TO DECEMBER, 1926, AS REPRESENTED BY THE DEVIATION OF MONTHLY AVERAGE FROM 3-YEAR MONTHLY AVERAGES (AFTER AUSTIN).

Fig. 10, from Austin's comparison of monthly averages for radio signal-intensity from two European stations, and for monthly averages of sunspots, is plotted over a six-year period. Here we recognize a general correlation, but without close agreement in detail.

We now come to some comparisons by Pickard (Fig. 11) over an eight-year period 1916–24 between averages of radio signal-intensities from the European station Nauen, as observed at the Bureau of Standards, and terrestrial-magnetic variations. Here again we find a certain degree of evident correlation although in details the agreement is not close.

Correlation of Sunspots with Radio Signal-strengths of Moderate Wave-length

We have thus far been discussing the relative behavior of long radio waves to sunspots or to terrestrial-magnetic variations. For present purposes, we may define long waves as waves exceeding one kilometer in length. We may now consider the behavior of moderately long radio waves (100 meters to 1,000

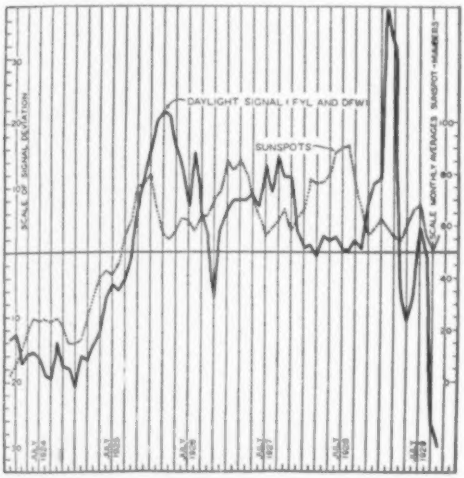

Fig. 10. Signal deviations of monthly signal-strength from 6-year monthly averages compared with monthly averages of sunspot-numbers, January, 1924, to October, 1929 (after Austin).

meters). American broadcasting-stations employ moderately long waves (200 meters to 550 meters). Pickard and Stetson have made records of the radio carrier-wave intensity from certain broadcasting-stations, and have compared them with sunspot-numbers during the same period. Fig. 12 is a diagram given by Stetson, of the Perkins Astronomical Observatory, for the evening radio reception from station WBBM of Chicago, plotted upwards during the three years 1926–28, and for the sunspot-numbers plotted downwards during the same period. Here a dis-

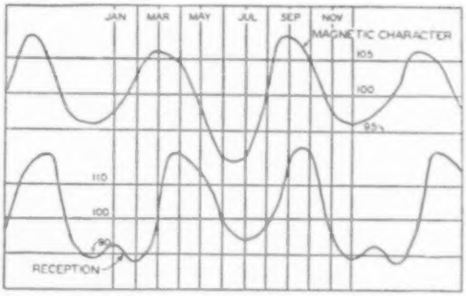

Fig. 11. Monthly averages of magnetic character of day and Washington day reception from station POZ, 1916 to 1924 (after Pickard).

tinct inverse correlation is indicated. Similar results have been reported by Stetson during a more recent period.

Diurnal Range of Virtual Height of Ionized Layer on Magnetically Quiescent Days

It is found that the virtual height of the ionized layer for short waves, that is, waves of from 10 meters to 100 meters in length, goes through a fairly regular diurnal variation in the absence of magnetic storms or perturbations. In general, the height is lower during daylight than during darkness, although the conditions vary in detail with the season and the locality. An explanation for this observed condition is suggested by the fact that during sunlit hours the upper air is exposed to active ionization by the Sun's rays, especially at the violet end of the spectrum; so that the number and den-

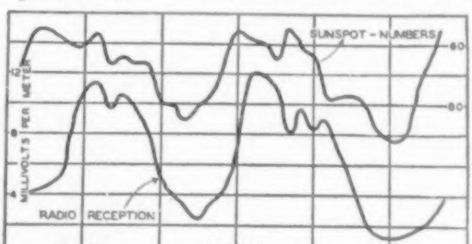

Fig. 12. Correlation between sunspot-numbers and signal-intensity, 1926 to 1928 (after Stetson).

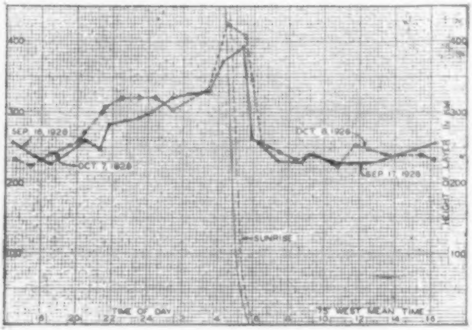

FIG. 13. DIURNAL VARIATION IN HEIGHT OF THE KENNELLY-HEAVISIDE LAYER ON TWO DAYS, SEPTEMBER 16–17 AND OCTOBER 7–8, 1928, FOR WAVE-LENGTH OF 70 METERS (AFTER TUVE, HAFSTAD AND DAHL).

sity of free electrons considerably increase, thus bringing the ionized layer lower. At night, on the contrary, neutralization of the gas atoms tends to occur, by the attraction between free electrons and ions.

Fig. 13 shows the range of virtual heights observed at the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, for waves of

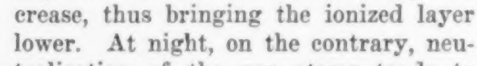

FIG. 14. VIRTUAL HEIGHTS OBSERVED OCTOBER 7–8, 1928: (*a*) AT MOORE SCHOOL OF ELECTRICAL ENGINEERING IN PHILADELPHIA, PENNSYLVANIA, (*b*) DEPARTMENT OF TERRESTRIAL MAGNETISM, WASHINGTON, D. C., ON TRANSMISSION FROM NAVAL RESEARCH LABORATORY, WASHINGTON, D. C., ON 4,435 KC (AFTER KENRICK AND JEN).

67.5-meter length, on two different days (September 16 and October 7, 1928). During the daytime the virtual height of the ionized layer was about 225 km; but this increased at night to about 400 km just before sunrise.

A pair of curves of diurnal layer-height appear in Fig. 14 for the day October 7–8, 1928, as observed concurrently at two different American receiving-stations. The waves of 67.5-meter length were emitted at the Bellevue Naval Research Laboratory, near Washington, D. C. The heavy curve shows the virtual heights as measured by Kenrick and Jen at the Moore School of Electrical Engineering in Philadelphia,

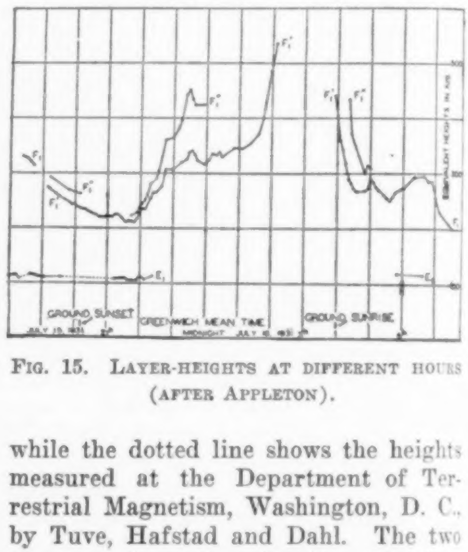

FIG. 15. LAYER-HEIGHTS AT DIFFERENT HOURS (AFTER APPLETON).

while the dotted line shows the heights measured at the Department of Terrestrial Magnetism, Washington, D. C., by Tuve, Hafstad and Dahl. The two curves are in good conformity. The daylight height was about 225 km and the darkness height about 400 km before sunrise.

Fig. 15 is taken from a recent paper by Appleton. It represents the virtual layer-heights measured at King's College, London, for waves of 80-meter length, during the day July 15–16, 1931, emitted from a sending-station in East London. Appleton points out that, during part of the time, reflections were obtained from the *E*-layer at a height of

about 110 km, as well as from a higher F-level. During the night, however, the E-reflections disappeared and the virtual height of the F-level rose to 500 km, when finally this layer disappeared until about sunrise.

A radio wave emitted near the ground from a simple vertical mast antenna is observed to be plane polarized, that is, its electric flux oscillation is in a vertical plane (following the electric current oscillations in the antenna); while the associated magnetic flux oscillation is in the horizontal plane of the ground.

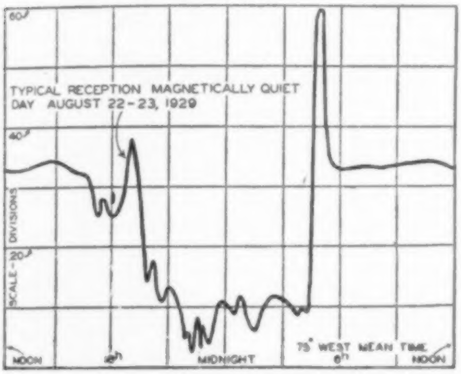

FIG. 16. TYPICAL RECEPTION FROM TUCKERTON (WCI) AT NEWTON CENTER, 16-KM WAVE, ON MAGNETICALLY QUIET DAY, AUGUST 22–23, 1929, SHOWING MARKED SUNSET AND SUNRISE PEAKS AND LOW NIGHT FIELDS (AFTER PICKARD).

Appleton finds that when such a wave passes through an ionized layer in a direction roughly parallel to the Earth's local magnetic field, the wave tends to split into two rotary polarized components, one right-handed and the other left. In the northern hemisphere, the right-handed component is retarded and absorbed by the layer more than the left; so that the received descending wave is found to be circularly polarized with left-handed rotation. In a recent[7] communication, he has described experiments

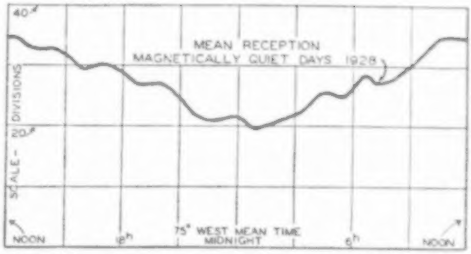

FIG. 17. TYPICAL RECEPTION FROM TUCKERTON (WCI) AT NEWTON CENTER, 16-KM WAVE, FOR THE MEAN OF MAGNETICALLY QUIET DAYS IN 1928 (AFTER PICKARD).

made in Australia, not remote from the magnetic pole of the southern hemisphere, and there the reflected wave has been found to possess right-handed circular polarization. Perhaps the two F-layer reflections in Fig. 15 correspond to the two rotary components into which the initial wave may be this decomposed.

EFFECTS OF MAGNETIC STORMS ON LONG-RANGE RADIO SIGNAL-RECEPTION

It is found that magnetic storms, as recorded in terrestrial-magnetic observatories, are not only apt to be accompanied by powerful stray currents in the crust of the Earth and by auroral displays in the upper air, but also by marked disturbances in radio signals, although the effect produced differs with the length of the radio waves.

Fig. 16 is a graph given by Pickard of diurnal signal-strength received at Newton Center, Massachusetts, on fairly

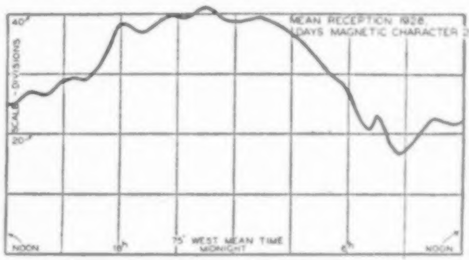

FIG. 18. TYPICAL RECEPTION FORM TUCKERTON (WCI) AT NEWTON CENTER, 16-KM WAVE, FOR THE MEAN OF DAYS OF MAGNETIC CHARACTER 2 DURING 1928 (AFTER PICKARD).

[7] E. V. Appleton, "Polarization of Downcoming Wireless Waves in the Southern Hemisphere," *Nature*, 128, 1037, 1931.

long radio waves emitted from the Tuckerton Station WCI, during a single magnetically quiescent day, August 22–23, 1929. Here the received intensity is fairly steady during the day, falls to a somewhat irregular low value at night, and shows sudden peaks near sunrise and sunset.

Pickard's corresponding graph for average reception during six months at and from the same stations on days of moderately quiet magnetic conditions appears in Fig. 17. There is now relatively little difference between day and night signal-intensity. The peaks have disappeared.

The conditions of diurnal average reception for days of magnetic disturbances or moderate magnetic storms are given in Fig. 18. Here the received signal-intensity at Newton Center is greater at night than by day, or there is a reversal of the quiescent conditions. Finally, Fig. 19 is Pickard's graph for reception-conditions during the severe magnetic storm of July 8–9, 1928. Here the signal-intensity is very distinctly greater during the night than during daylight hours, showing a marked inversion of the conditions existing on magnetically quiet days.

In Fig. 20 we have some graphical analyses reported by Anderson, of the American Telephone and Telegraph Company, for the radio signal-intensities of long transatlantic waves, in the year 1927. The central line of each diagram represents the onset of the storm, and

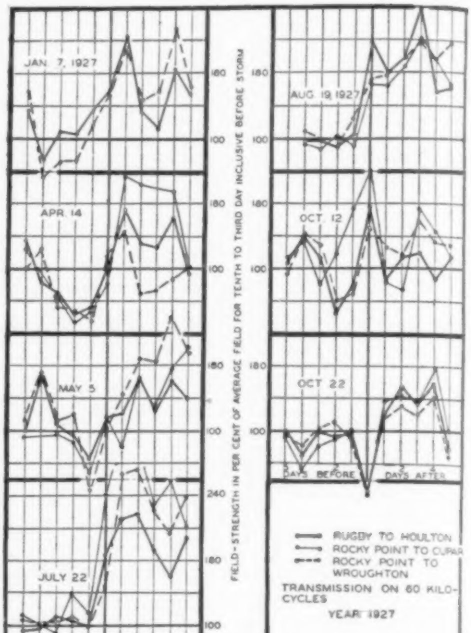

FIG. 20. EFFECT OF SOLAR DISTURBANCES ON 60-KCS DAYLIGHT RADIO TRANSATLANTIC TRANSMISSION IN 1927, SHOWING CORRELATION OF LONG-WAVE RADIO RECEPTION AND MAGNETIC STORMS (AFTER ANDERSON).

seven storms are separately considered. The mean signal-strength is plotted for each of the five days before and after the storm, on three distinct radio transmissions. The curves tend to show that for these long waves (5 km), the signal-strength increased distinctly for a few days after a storm.

A similar result is reached in Fig. 21, which represents an analysis by Austin and Wymore for the signal-strength received at the Bureau of Standards during the years 1925–27 from several long-wave European stations. The deviations attributable to magnetic storms are plotted for five days before and after the onset. There is a distinct rise in signal-strength following a storm, reaching a maximum in about two days and falling back to normal in about three days more.

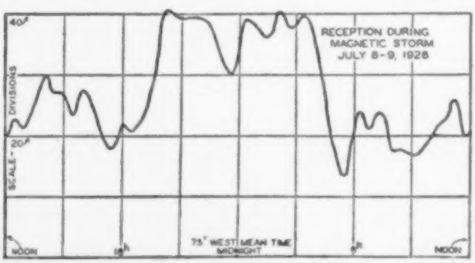

FIG. 19. TYPICAL RECEPTION FROM TUCKERTON (WCI) AT NEWTON CENTER, 16-KM WAVE, DURING SEVERE MAGNETIC STORM JULY 8–9, 1928, SHOWING MARKED INVERSION (AFTER PICKARD).

On the other hand, the effect of a magnetic storm on the reception of short radio waves crossing the Atlantic, seems to weaken them greatly. Anderson's analysis of the effect of a magnetic storm on July 8, 1928, appears in Fig. 22. The thin broken line indicates the variation in the horizontal component of the Earth's magnetic field; while the heavy line indicates the strength of short-wave radio transmission from Deal, New Jersey, to New Southgate in England. These two lines follow together remarkably. They show a falling off in radio reception commencing two days before the center of the storm, reaching a minimum at the time of greatest magnetic disturbance, and returning to normal after about six days. At the same period, the long-wave radio signals (5,000 meters) from Long Island, New York, to Cupar in Scotland, increased instead of dwindling, during and after the storm.

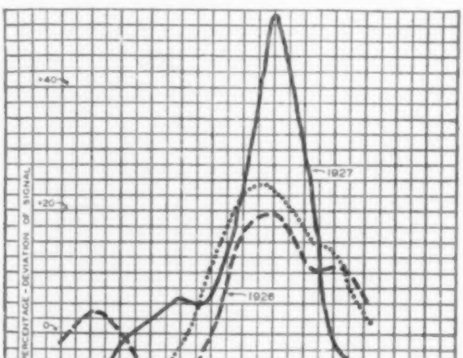

Fig. 21. Average daily deviation from monthly mean of daylight field-strength of signals from stations in Europe during progress of magnetic storms 1925, 1926, 1927 (after Austin and Wymore.)*

* Note correction in Fig. 21: The dotted-line curve should be dated 1926, and dashed-line curve 1925.

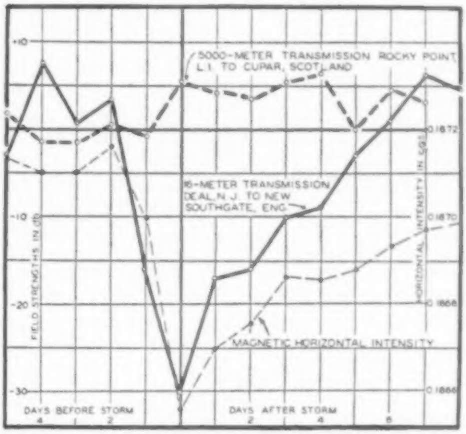

Fig. 22. Variation in radio transmission for 16-meter and for 5,000-meter transatlantic signals, showing correlation with magnetic storms (after Anderson).

Although there is little known, as yet, concerning the influence of magnetic storms on radio wave-transmission, yet the suggestion has been offered by several observers that during magnetic storms there is likely to be an increase in the depth and density of the ionized layer. This tends to improve the reflection and transmission of long waves. On the other hand, the short waves which are supposed to be reflected back to ground from higher levels, are likely to suffer excessive attenuation, by absorption in the lower layers.

Sunspot-cycles and Cycles of Terrestrial-Magnetic Activity

That there is a clear correlation between sunspot-cycles and cycles of the Earth's magnetic activity is borne out by Fig. 23, which compares annual sunspot-numbers with corresponding annual magnetic activity, as tabulated at the Department of Terrestrial Magnetism, over the period 1834–1930 or nearly 100 years. The upper curve follows the magnetic activity, and the lower the sunspot-numbers. Although the details of these curves often differ, yet the general agreement is remarkable. There appear to have been 8 com-

plete cycles of each of these two curves, between the peaks of 1837 and 1928, or an average of about 11.4 years per cycle. Why the Sun should exhibit an eruptive habit of this period is still mysterious. It has been suggested that possibly both series of phenomena may be concurrent symptoms of cosmic influences even more remote than the Sun. At the present date (1932), we are descending to an expected minimum of both sunspots and magnetic activity due in or near 1934.

Two theories have been advanced for the correlation between spots on the Sun with magnetic changes, as well as ionized-layer and radio disturbances on the Earth. These two theories are perhaps not mutually exclusive. One emphasizes the ejection of finely divided matter from the surface of the Sun in jets, which move outwards at high speeds, and, if favorably directed, may reach the Earth's atmosphere in such a manner as to set up strong electric currents, auroral discharges, ionization, etc. The other emphasizes the action of ultra-violet light emitted from the sunspots and the ionizing influence[8] of this actinic radiation on the Earth's atmosphere.

nounced the discovery[9] in Oslo, Norway, of radio echoes following short-wave signals (31.4 meters) emitted from a sending-station at Eindhoven in Holland. These delayed echoes have since been recognized by various other observers, although they seem to be very rarely detectable in European latitudes (35°–60° north). The delay of echoes recorded oscillographically from the ionized layers of the upper atmosphere is ordinarily from about 1 to 4 milliseconds. The delayed echoes, here considered, have been reported as following the generating-signal by an interval of from 1 to 30 seconds, a totally different order of magnitude. A great many of such delayed echoes were reported by J. B. Galle, at the island of Pulo Condore[10] in the tropics, during a French expedition to observe a solar eclipse which was total at that locality in May, 1929.

Two theories have been suggested to explain these extraordinary radio echoes. One was that the signal-ray penetrated the space between upper and lower ionized atmospheric layers, became greatly slowed down in group-velocity, oscillated to and fro between the layers, and finally returned to the ground after great delay. Pederson

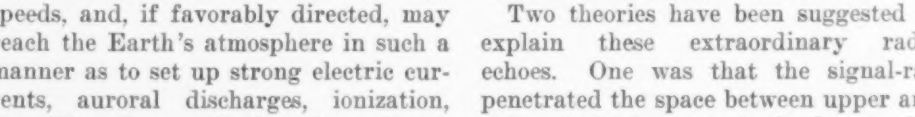

FIG. 23. CORRELATION BETWEEN SUNSPOT-NUMBERS AND MAGNETIC ACTIVITY, 1836 TO 1930 (AFTER DEPARTMENT OF TERRESTRIAL MAGNETISM).

RADIO ECHOES OF LONG DELAY

In 1927–28, Störmer and Hals an-

has shown that this theory is very unsatisfactory, for several reasons.

The other theory, put forward by Störmer, is that when cathode-rays

[8] E. O. Hulburt, "Tables of the Ionization of the Upper Atmosphere," *Phys. Rev.*, 39, 977–992, 1932.

[9] Carl Störmer, "Short-wave Echoes and the Aurora Borealis," *Nature*, 122, 681, 1928; also "Ueber die Probleme des Polarlichtes," Ergebnisse der kosmischen Physik, 1, 1–86, 1931.

[10] J. B. Galle, "Observations relatives à la radioélectricité et à la physique du globe faites à l'occasion de l'éclipse totale de soleil du 9 mai 1929 à Poulo Condore (Indo-Chine)," *Onde Électrique*, 9, 257–265, 1930.

emitted by the Sun move towards the Earth there is, for a given stream-velocity, a certain radial distance from the Earth which they can not enter in a straight line, being deflected by the Earth's magnetic field. Under the influence of this field, the cathode-ray stream would carve out a toroidal hollow space, shaped like an apple, coaxial with the Earth's magnetic polar axis. The ionized walls of this toroidal space, at a radial distance of perhaps two millions of kilometers from the Earth, would be capable of acting as an ionized layer and of reflecting the waves back to the Earth, which is at the center of the tore. A short-wave radio signal capable of penetrating and emerging from the atmospheric ionized layer, would proceed as a straight ray to the toroidal surface, and when reflected back to the Earth, would make a journey of say 4,000,000 km, which would occupy about 13 seconds. Different velocities and masses of ionized streams, approaching the Earth, could set up toroidal reflectors at different distances.

Many more observations will be necessary to confirm or refute this ingenious theory of long-delayed echoes. Fig. 24, from one of Störmer's publications, indicates the incoming electronic streams descending to the Earth in curtain-like sheets around the Earth's magnetic poles, and forming, under favorable conditions, visible auroral clouds.

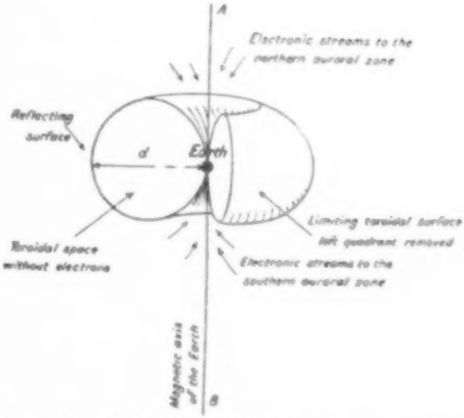

Fig. 24. Diagrammatic sketch of theory for long-delayed echoes (after Störmer).

Conclusions

It is evident that there are widespread cosmic influences which affect the magnetic field, auroras, the ionized air-layer and radio signals, at or near the surface of the Earth. Within the last few decades, radio has become available as a new research tool for exploring the upper air all round the world. The conjoint organization of a man directing a locomotive or an airship is a creative combination of much larger powers and radius of action than the same man unarmed. Since a properly equipped operator at a powerful radio station can invade the atmosphere up to say 200 km, the height of the ionized layers, all round the world, the conjoint organization of operator and radio becomes a spherical combination 40,000 km around, hollow, and 200 km thick. Moreover, if Störmer's theory of delayed echoes should be confirmed, the same operator, armed with radio waves, would become a conjoint organization with a toroidal sphere of influence having a radius of more than a million kilometers. In any event, careful study of radio wave-phenomena should enable the upper atmosphere to be explored to elevations that have heretofore been inaccessible to man.

In a certain sense, it is fortunate that the relations between radio wave-propagation and the various cosmic phenomena here considered, are so complex. If radio waves of all lengths were subject to one and only one simple law of transmission in passing through the Earth's atmosphere, the law might be easy to determine, but it could not be expected to elucidate the behavior of

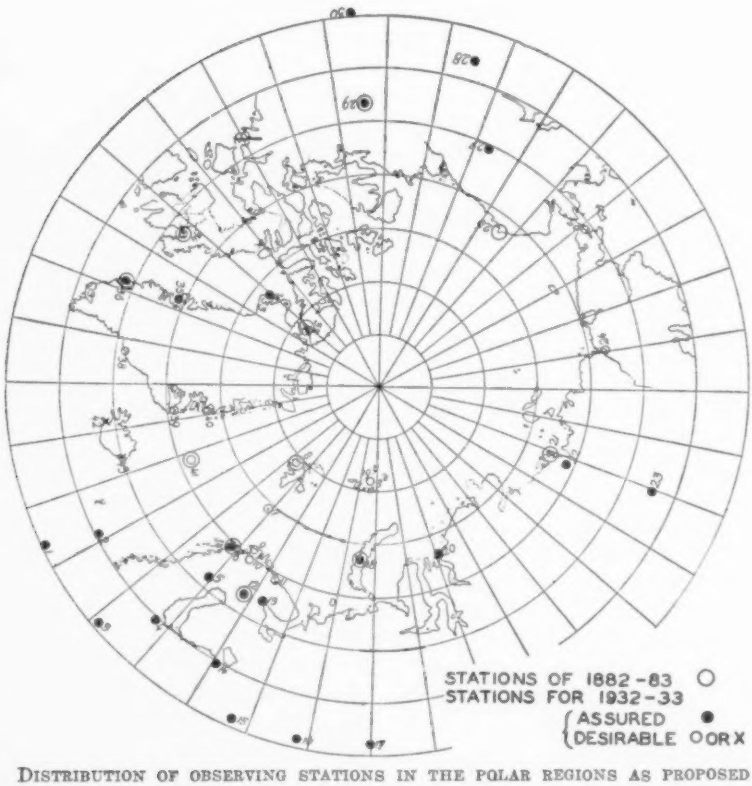

FIG. 25. DISTRIBUTION OF OBSERVING STATIONS IN THE POLAR REGIONS AS PROPOSED FOR THE INTERNATIONAL POLAR YEAR 1932–33 (AFTER INTERNATIONAL POLAR YEAR COMMISSION).

other cosmic influences. The transmission of radio waves is, however, dependent upon a number of conditions, including direction, wave-length, magnetic and electric phenomena, which make the problem more difficult, but promise much collateral information when it is finally solved.

Fig. 25 is a map of the northern polar hemisphere prepared by the International Polar Year Commission to show the magnetic stations that were occupied successfully by expeditions from more than twelve different nations in the "Polar Year" 1882–1883; also the stations that it is proposed to occupy during the forthcoming "Jubilee Polar Year," 1932–1933. The various nations will carry out a concerted program of meteorological, magnetic, electric and radio work, which should lead to the acquisition of much needed knowledge in all these directions. It can not be doubted that all such knowledge will lead to results of international importance and utility.

CARBONATION OF DAIRY PRODUCTS

By Professor M. J. PRUCHA

DEPARTMENT OF DAIRY HUSBANDRY, UNIVERSITY OF ILLINOIS

UNDER ordinary conditions, carbon dioxid is a gas; when compressed under a high pressure it is changed into a liquid; and when subjected to a low temperature of about 150 degrees F. below zero it is changed into a solid. In this latter condition it is known as "dry ice." It is readily soluble in water. The amount of it that can be dissolved in water depends on the temperature of the water and on the pressure under which the water is held. When it is dissolved in water or in beverages, it imparts to them a pleasant pungent taste which is greatly relished by some people. Carbonated beverages are well-known articles of commerce.

Carbon dioxid could be classed as a preservative and a mild germicide. If enough of it is dissolved in a beverage, it will stop the bacterial multiplication therein and thus will prevent the deterioration and the spoilage of the beverage. If the amount of carbon dioxid is further increased so that a pressure is produced in the sealed container, it will not only stop the bacterial multiplication but will also destroy most of the bacteria in the beverage. To bring about this result in soft drink beverages, it is necessary to carbonate them at a pressure of about seventy pounds. Here, also, it might be added that the carbonated beverages seem to possess a certain medicinal value for the digestive system.

In the dairy industry the loss due to the deterioration in quality and to the spoilage of milk and milk products is very great. An effective sanitary control of milk and milk products has been, and still is, an important and puzzling public problem. If the carbonation of soft drink beverages prevents their spoilage, makes them more sanitary and gives them a desirable flavor, will it also impart the same or similar benefits to milk and milk products? An answer to this question was sought in the experiments conducted in the dairy bacteriology laboratories of the department of dairy husbandry of the University of Illinois. From these experiments the following conclusions were reached.

The fluid dairy products such as fresh milk, evaporated milk, cream, ice-cream mix, and various milk drinks can be carbonated in two different ways.

One method consists in dissolving carbon dioxid in the dairy products until a saturation point is reached and then storing the products in the usual dairy utensils such as milk cans which can not be sealed air tight. The carbon dioxid under these conditions gradually escapes. This manner of carbonation tends to prolong the keeping quality of the products but does not prevent the deterioration or the spoilage of the products. The length of time that a dairy product so carbonated can be kept before spoiling depends on the temperature at which it is kept and on the number and kind of bacteria present in the product before it is carbonated. Many of the acid-producing bacteria are able to grow in presence of carbon dioxid. When the dairy product is pasteurized at a temperature of about 170 degrees F. so as to kill the acid-producing bacteria and is then carbonated, its keeping quality will be materially prolonged. For example, evaporated milk carbonated and stored in milk cans in a refrigerator at a temperature of about 40 degrees F. remained in an excellent condition for a month, while the same milk, not carbonated but kept under the same conditions, spoiled in two weeks.

This manner of carbonation will prob-

ably not be practical for the preservation of fluid sweet milk. It could, however, be used with profit for evaporated milk and for ice-cream mix. These two products are prepared at the source of milk supply and may be transported long distances or stored for future use. The carbonation of these products as soon as they are made would materially improve their keeping quality.

The other method of carbonation of fluid dairy products is carried out by putting the product in an air-tight strong container and then introducing enough carbon dioxid to produce a pressure in the container. Milk can be preserved in the same manner as are the soft drink beverages, except that a much higher pressure is required.

In one experiment milk of good quality was carbonated under a pressure of 180 pounds and then was stored for one month at 45 degrees F. This manner of carbonation completely inhibited all bacterial multiplication during the storage period and it also killed most of the bacteria that were present at the start so that the milk became practically sterile. There are certain difficulties involved in carbonation of milk in this manner. It could, however, be utilized in connection with the transportation of fresh milk for long distances, such as ocean voyages.

The carbonation of milk drinks, such as chocolate milk and milk drinks prepared by adding various kinds of flavors to the milk, deserves special attention. In the first place the pungent taste due to carbon dioxid seems to improve the taste of these milk drinks, and secondly the carbonation, if done properly, will materially prolong their keeping quality. The best results from the standpoint of flavor were obtained when the drinks were carbonated in sealed bottles to a pressure of about 40 pounds. These milk drinks could also be put up in the ordinary milk bottles after being carbonated. In this case a much smaller amount of carbon dioxid can be put into the milk and it tends gradually to escape from the bottled milk so that the benefits due to carbonation are not so lasting as when carbonated in sealed bottles.

Experiments were also conducted with solid dairy products, such as butter, cheese, and powdered milk. The method of carbonation of these products consisted in storing the products in the atmosphere of carbon dioxid in an air-tight container. Butter so treated and then stored in cold storage did not deteriorate in quality so soon as similar butter kept under the same conditions except that it was in the air instead of carbon dioxid. It was also noticed that the mold which frequently spoils the butter did not grow in carbon dioxid and that the off-flavors which are due to the oxidation of certain ingredients of the butter did not seem to develop.

The same thing was true of cheese and of powdered milk, namely, that the undesirable flavors that develop as a result of oxidation were largely inhibited by the carbon dioxid. It should also be observed that when cheese was stored in carbon dioxid atmosphere in a sealed container it did not mold. It is a common observation that cheese may spoil very readily owing to the rapid growth of mold on its surface. This fact has seriously interfered with the packaging of cheese for retail trade. Putting up small packages of cheese in sealed containers in carbon dioxid atmosphere might help to solve the packaging of good cheese and might increase the cheese consumption.

Considering all the phases of the problem of carbonation of dairy products, it might be concluded that carbonation of some dairy products is feasible, that it improves their taste, their keeping quality, their sanitary quality and that it might be financially profitable. Carbonation of certain dairy products is not practical nor would it be financially profitable.

SHADE TREES THREATENED BY INSECT PESTS

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EARLY last August a severe wind storm, a near tornado, brought ruin and destruction to many trees in Westport and Fairfield, Connecticut. Large trees were uprooted and those securely anchored to the soil suffered the loss of good-sized limbs. These latter were twisted off and their condition suggested the work of a mighty giant. Something like 2,500 trees were damaged by this storm, and the loss could easily be placed at a quarter of a million dollars. Trees were wrecked in the thickly settled village as well as in the more open country, and those familiar with the situation pronounced it a tragic loss. There is no question but that such was the case. It was a cause for thanksgiving that no lives were lost.

The sudden sweep of the elements and the speedy destruction of thousands of trees capture the human imagination. It is a newspaper story. Every one is interested. There is not the same news value in insect depredations and yet these latter may easily exceed in magnitude and loss the damage resulting from a number of storms, such as the one we have briefly described.

The seriousness of the insect situation in relation to shade trees in the northeastern United States was brought to attention very forcibly last summer. Yet it had not attracted any great amount of notice either from individuals or the press. It is more than probable that comparatively few realize what has actually occurred. Furthermore, it is difficult to get at precise data in relation to this. It is a matter of great importance, so far as our shade trees are concerned, because the effect of the injuries last season will continue to be felt for several years and may produce a very marked change in the shade tree situation. Three insects in particular have caused what might be classed as major damages to shade trees in the northeastern United States. These are the elm leaf-beetle, the Japanese beetle and the European willow-leaf beetle. Who knows how many trees have been affected and the probable outcome?

Estimates made last summer indicate that approximately 100,000 elms in southern Connecticut were seriously damaged or entirely defoliated by the elm-leaf beetle. As many more were seriously injured in the other New England states and some 250,000 in New York State. The Insect Pest Survey of the United States Department of Agriculture recorded serious injury last year by this insect from the New England States and also from New York, Delaware, Maryland, Virginia, Ohio and Kentucky, and from the Far West, namely, Oregon and California. There must have been, surely, at least 200,000 trees in the areas not previously included which were seriously affected by this pest. This brings the estimated total of seriously damaged elms in the northeastern United States to 650,000. These estimates take no account of the trees on private property. These latter would easily equal in number those upon the streets and highways, and the presumption is that an equal number were severely damaged. This brings the grand total of elms seriously damaged last year by the elm-leaf beetle to over one and one quarter million, namely 1,300,000 trees. This is surely a tre-

mendous levy upon the vigor and vitality of one of the most valuable and highly prized of our shade trees. The probabilities favor as much if not more damage the coming season. Communities which suffered severely from elm-leaf beetle last summer may well take warning. The wide-spread injuries by this pest in the Hudson River Valley early in the century resulted in the death of many valuable trees and, as a consequence, communities in that area were practically forced to adopt systematic control measures. Is it too much to hope that the experience of 1931 will result in better protection for the trees in many other localities?

This by no means completes the shade tree story for last year. Those who had occasion to travel in the generally infested Japanese beetle area in 1931 could hardly have failed to note the very general defoliation of trees in a section centering approximately on Philadelphia and extending south to Wilmington, Delaware, and north to Trenton, New Jersey, or thereabouts. It would seem entirely within probabilities that at least a quarter of a million trees may have lost their foliage as a result of the work of this destructive insect. The pest is a general feeder. It shows a marked preference for horse chestnut, linden, elm, willow, apple, peach, sweet cherry, plum, rose, grape, Boston ivy and Norway maple, to mention some of the trees and vines upon which it feeds most readily.

The situation in regard to the Japanese beetle is somewhat different from that in relation to the elm-leaf beetle. This more recent pest attacks a considerable variety of trees and shrubs. It is erratic in its habits. It is spreading rapidly in spite of governmental efforts to check dissemination. The serious damage to shade trees and ornamentals of the generally infested area is destined to be spread over the sparsely infested area which now takes in parts of Virginia, Maryland, Delaware, Pennsylvania, all New Jersey, the southern part of New York, all Connecticut and Rhode Island and two good-sized areas in Massachusetts. These are not the ultimate limits. They simply represent the recorded distribution of this insect to date. The available information indicates the Japanese beetle is controlled fairly well under average horticultural conditions, since the spraying necessary to protect fruit trees from various insect pests ordinarily controls this insect satisfactorily. Such is not the case with ornamentals. It usually means an additional spray and the repeated defoliations, with the inevitable extension of these areas, raises a serious problem.

The third insect in this deadly trio is the European willow-leaf beetle. It is now widely distributed in southern New England, New York and south to New Jersey, Pennsylvania and Maryland. Fortunately, in one respect, the willow does not occupy a very important place as a shade tree. Yet it is somewhat generally grown, and in many sections of the infested area it has been severely damaged by this recently introduced pest. The number of willows defoliated in the eastern United States in 1931 were approximated at 200,000, though it must be admitted that this is a tentative estimate. The willow leaf beetle produces three generations annually, and when conditions are favorable largely prevents the foliage from functioning. The inevitable result is that the trees are weakened. They are certainly far from beautiful when the leaves are changed throughout most of the summer from a bright green to a hideous gray. The situation is made even more serious, so far as the willow is concerned, by the recently discovered willow scab fungus and the very general infection, serious injury and killing of many trees in New England at least.

In addition to the above, the beautiful larch suffered greatly the past summer from the depredations of the larch case bearer. The foliage of this tree was partly to mostly destroyed in southern New England north into the Berkshires of Massachusetts, New Hampshire and probably Vermont, and in corresponding areas in New York State, including extensive tracts in the Adirondacks. A large proportion of these larches were forest trees and yet there must have been many thousands, probably 250,000, which could be classed as ornamental or shade trees. Here again, timely spraying would have prevented serious damage.

Summarizing, it may be stated that insect depredations on shade trees in 1931 affected some two million trees, and this damage was caused by four introduced insect pests. Most of the trees affected were handsome specimens. Some stand upon the lawns of magnificent estates. Not a few are highly prized for sentimental reasons. These trees might easily be worth an average of $100 each. Their total value may thus be placed at $200,000,000. These extended depredations occurred without exciting any great amount of apprehension. No one has suggested that it might be due to the depression. Even tree owners gave it comparatively little attention. The statements of tree experts in not a few cases have been disregarded, possibly because it was thought that their representations were dictated by personal interest. On the other hand, no men are better qualified to pass upon the probabilities in regard to insect depredations than those who are giving their entire time to shade tree welfare. As a scientist interested in the proper solution of this problem, the writer wishes to call attention to the effects likely to result from this situation.

In the first place it must be admitted that a comparison between 2,500 trees damaged by a storm early in August, 1931, in southern Connecticut with the presumably two million trees defoliated by various insects, suggests that the latter may be much more serious than the former, so far as the welfare of shade trees is concerned. We would not belittle the storm damage. That was very severe. On the other hand, defoliation or destruction of the leaves means serious injury, and it was the fate of a vastly greater number of trees.

What is the probable outcome of this extensive defoliation?

In the first place, if we go back to the early part of this century and scan the history of the elm-leaf beetle in the Hudson River Valley, it will be noted that very serious damage was recorded in some communities and this was representative of many other localities. In the cities of Albany, Troy and Watervliet, it was estimated then that fully 4,000 trees had been destroyed by the pest. These were magnificent shade trees. They succumbed after several successive years of defoliation. Observations at that time indicated that the loss of foliage three successive seasons practically ruined trees, and in the case of those with a reduced vigor was frequently followed by death. The extensive studies of earlier years on the gipsy moth in eastern Massachusetts resulted in similar conclusions in relation to various shade and forest trees. A number of communities which suffered most severely from elm-leaf beetle in those earlier days took the lesson to heart and made more or less adequate provision for the protection of the trees. It was about this time that a number of the other communities in the northeastern United States took steps in this direction, and as a consequence wide-spread ravages of this and other insects were checked.

To return to the picture before us, we have presumably two million trees which

were seriously damaged by insects the past season. Not a few of these were defoliated the preceding year. The probabilities indicate serious injury in 1932. This is practically certain to result in the case of the Japanese beetle and the willow-leaf beetle. The elms are very likely to suffer as they have during the past season. Is it wise to wait longer? One can not do much with a dead elm. Furthermore, many of these trees are not in a condition to stand repeated defoliations. Numerous limbs are in a weakened, sickly condition. Some may even jeopardize public safety. There is a possibility of damage claims in the case of an accident. Can tree owners afford to take these risks?

The time is approaching when it will be necessary to provide systematic protection for shade trees. The need is rapidly becoming as great as in the case of fruit trees. It would be folly to attempt to grow fruit on a commercial scale without making provision for the control of insect pests and fungous diseases. The time is coming when the need of systematic protection for shade trees will be generally recognized. It has come in the case of some localities.

It requires no great foresight, with these facts before us, to draw the conclusion that if the conditions of 1931 are allowed to continue, many thousand shade trees will succumb to natural causes within the next few years. These untoward results will undoubtedly be greatly hastened by an abundant crop of various boring insects, such as the elm borer, the elm snout beetle and the common flat-headed borer. Other trees may be expected to suffer greatly from borer attacks. Many oaks are killed each year by the two-lined chestnut borer. A deadly bark beetle is attacking and killing many hickories. These and other borers thrive in trees which have been weakened from one cause or another, and as they increase in number they attack and destroy trees which would ordinarily successfully resist invasions of this character.

There is no question as to the possibility of controlling these insects and dealing with the situation in a practical way. The principal difficulty is to secure a general realization of the value of shade trees and the fate likely to befall them unless there is protection. The communities which have suffered greatly from the work of various insect pests may well give the entire problem serious consideration. A decision should be made shortly as to whether such conditions are to be allowed to persist or whether it is advisable to face the problem and make provision for control.

A very great proportion of these trees are 50 to 100 years old. They can not be replaced in any considerable numbers in less than one or two generations. Ordinarily a magnificent elm or other tree 100 to 200 years old is much more satisfactory than a recently planted sapling. We can not escape the conclusion that a continuance of present conditions means a much more rapid loss of shade trees than can be justified. We are allowing a natural resource to be wasted. We are sacrificing esthetic as well as material values.

There is also the practical aspect to be considered. It may actually cost more to remove some of these giants than it would to provide protection, such as spraying and pruning, through a series of years. Furthermore, the cost of cutting out the dead wood in weakened trees may easily exceed the cost of spraying for two or three years, and the results are much less satisfactory. There is no getting away from these facts. There is now a choice for the owner or community concerned. There is no choice after the trees have died. The time limit may expire much sooner than many expect.

WHAT IS LEARNING?

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THE importance, for educational theory and practice, of an intelligible account of learning is clear. The persistent confusion about what learning is and how it happens is largely due to a smoke-screen thrown about the topic by the old psychology, with its jealousy of physiology. Methods of teaching, techniques of training and guidance, will continue to be hit and miss until educators realize what a simple and unmistakable process learning really is.

As a text for further discussion I shall take an account from the most recent pronouncements of one of the most esteemed writers[1] on learning. In this account the author first reviews briefly some of the attempts to explain the establishment of "connections." The "law of effect" is advocated and it is said that "One conclusion we may draw with some surety from the evidence. . . . The consequences of a connection seem to act on it directly at the time, as well as, or instead of, acting on it indirectly by causing some repetition or rehearsal or consideration of it, or by adding some motive or reason for it."

We are then asked to consider "some of the simplest cases of all learning," being assured that only the feature of "time interval" distinguishes these from "the stock experiments with animal and human learning." The case adduced is the following:

> Let a young kitten that has never had any experience with fish or meat of any kind be confronted with a row of small flakes of cooked fish, identifiable by shape, color and smell.[2] It will examine and eat one flake. Another piece is set before it, and it repeats the examination (probably abbreviated) and the eating. And so on, so long as it is hungry, with abbreviation of the examination and full retention of the eating.
>
> The same kitten confronted in the same way by a row of small friable capsules covered with meat juice but containing weak acid will examine them and may take one into the mouth. It will not repeat the act often but will soon avoid the capsule.
>
> One connection is retained, perhaps strengthened, and so acts again and again; the other is soon so weakened that it ceases to act at all. . . . In either case, the influence of the consequences seems direct.

With his usual direct touch, Thorndike has here picked a perfect example of all that is essential in learning. But in line with the current and historical predilection, he seeks for the learning in just the wrong place. Note that in neither case is any connection weakened, nor does any response cease to occur. Eating fish cakes continues to be the final response to the cakes. Avoidance continues to be the final response to the acid capsules. What precisely is it that happens in these cases, then?

The learning, as is even clearly indicated in certain unemphasized words in the quoted paragraphs, consists in an abbreviation of the examination. The "response," the terminal act, remains just what it initially was—in the first case "eating"; in the second case "avoidance." Let us look at the facts more closely.

The first kitten did not eat until after a prolonged examination. Before "eating" occurred, the first time, the kitten had to see, smell and taste the fish flake. Next time it abbreviated the examination. Upon seeing and smelling only, it bolted down the fish. Next time the

[1] E. L. Thorndike, "Human Learning," Scribners, New York, 1931.

[2] We should add "identifiable also by taste."

smelling also was dispensed with. Sight of the fish flake led to gulping it down.

The response remains unchanged. But the requisite antecedent or stimulus, called by Thorndike the "examination," is "abbreviated." There is then a reduction in the stimulus or cue necessary to instigate the unmodified response. And this cue reduction is what we mean by learning.

Consider now the second kitten. "Avoidance," we are told, was the terminal act, in the case of the acid capsules, smeared with meat juice. How was it learned, or in what did its learning consist? Initially, sight, smell and taste were all required to provoke it. Later, sight and smell sufficed. Finally, a mere glimpse of the capsules led to avoidance. Again the cue required for the terminal act is reduced. The examination is abbreviated. The response remains unchanged. And that is learning, namely, cue reduction.

Either sight, smell or taste, when the thing is "learned," suffice to provoke behavior which initially required them all. What the behavior will be depends of course on the nature of the stimuli and the native or previously acquired repertoire of the learned. In general, the terminal act may be described as one that eliminates the stimulus or irritant. Eating the fish cakes eliminates them; avoiding the capsules also eliminates them as effective stimuli.

Any case of learning ever observed can be described (and thus explained) in terms of this general tendency of living protoplasm to respond to reduced cues. It is no peculiarity of neurones, and no speculation concerning the esthetics or the social life of neurones is needed to make it intelligible.

The elementary thing about learning is a change in the stimulus, not a change in the response. As for the "connections," there is no reason to speculate about them; single neurones, so far as we now know, are individually capable of reacting to reduced cues, just as other unicellular creatures are. There is even reason to suppose that muscle cells and blood corpuscles do the same thing. And as for the statistical probabilities, they remain unchanged, and hence "connections" cannot refer to statistics. The very first time the sight of fish cakes led to eating; the sight of acid capsules led to avoidance. They did not, of course, do so *immediately,* but only with the contribution of various other joint stimuli, such as smelling and tasting. It is the elimination of the necessity for these originally requisite "contributing stimuli" that gives us the phenomenon of learning.

There is therefore just one principle that the educator needs to be in possession of, although there are of course many complex details connected with its successful administration. This single principle of education, stated in its most general terms, is—"First discover what antecedents are now required to provoke the desired consequent. Then proceed to effect a reduction in the scope of this antecedent until the expedient degree of cue reduction is achieved. The techniques of cue reduction comprise the details or subject-matter of the science of education. Education, in its most explicit form, involves just four achievements:

(a) The behavior that is desired needs first to be determined (by the teacher, the public, the philosopher, the pupil, or whomsoever is charged with this responsibility).

(b) A situation needs then to be found which will eventuate in this behavior. If it be desirable that some particular cue be made effective, this must be embedded as a detail or partial feature in this provoking situation, in such a way as not materially to modify the total response.

(c) By one or more of the various techniques this total provoking stimulus

complex must then be reduced. That is, various partial details of it, or the special details determined upon in advance, are made effective cues.

(d) If possible, sagacity must be promoted. This is simply the cooperation of cues, at least one of which functions for the general life situation or occasion, thus giving the act what we call "relevance." This is what Thorndike calls "having the neurones act with reference one to another." Whether or not this is a modifiable human trait is still doubtful, although it is clearly a variable trait within and among individuals. Capacity for it is one of the most essential mental traits.

A somewhat trivial example will serve the purpose of illustration of these four fundamental aspects of teaching. Suppose that the social philosopher, or the law, or the teacher, or a class committee should decide, at least for the moment, that boys should tip their hats to ladies. We now plan the education of such a pupil.

We discover that initially, when a woman is present, and we say to the boy "There is a lady! Now tip your hat! Watch John and do as he does! See, this is the way I do it! Go ahead now!"—thereupon he tips his headpiece.

Quite an elaborate stimulus complex, requiring (a) the presence of a woman; (b) the use of indicative and imperative language, with a long history of learning behind it; (c) concrete example by some "learned" person.

Learning has been achieved when in response to any of these cues, singly, the act results. Let us say the process is continued (simple repetition will do the trick; vividness helps; attention is also a great aid; proper distribution of practice is useful, and so on through all the rules), until the appearance of a female figure now touches off the hat-tipping.

But, after all, learning is not enough. Learning alone, without sagacity, makes neurotics. Mere learning would lead this boy to tip his hat to every magazine cover, and to half the pictures in the art gallery. It would even lead him to keep on tipping his hat repeatedly so long as the lady remained in his presence. And this would be a neurosis.

Certain other cues, from the general environment, must also be rendered effective (also of course through learning). Thus the sight of the picture frame, the feeling of having just tipped the hat, etc., would be cues leading to leaving the head-gear alone. But this effectiveness of contributing or guiding cues from the present context (as distinguished from past contexts) is what we mean by sagacity.

Learning can accomplish much. Without learning, indeed, there could be no sagacity. But there can be learning without the latter. Without sagacity, learning is as a sounding brass or a tinkling cymbal. It will function regardless of the occasion. Even if sagacity can not be taught, as perhaps it can not, any more than stature can, it may be perhaps promoted. That is, the educator can know the conditions favorable to it. The pupil can be led to discover these favorable conditions and perhaps to foster them in his own life. An emotional attitude, for example, interferes with sagacity, and emotions may perhaps be avoidable to some degree by giving thought to the matter.

Three of the educational problems, therefore, have to do directly with cue reduction (learning). And even the guiding cues involved in sagacity act on the basis of previous learning. If, then, there is a simple and intelligible account of the nature of learning, educational psychology should know it. Our contention is that this is the case—that learning is cue reduction. To understand learning does not require any inferences whatsoever about the neurones, although these also may learn.

WAS THERE A SUICIDE "WAVE" AMONG COLLEGE STUDENTS IN 1927?

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DURING the first three months of 1927 the American press gave unusual prominence to some twenty-six suicides by college students, mostly young men from eminent families. The public was led to believe that an epidemic of self-destruction had spread through our institutions of higher learning.

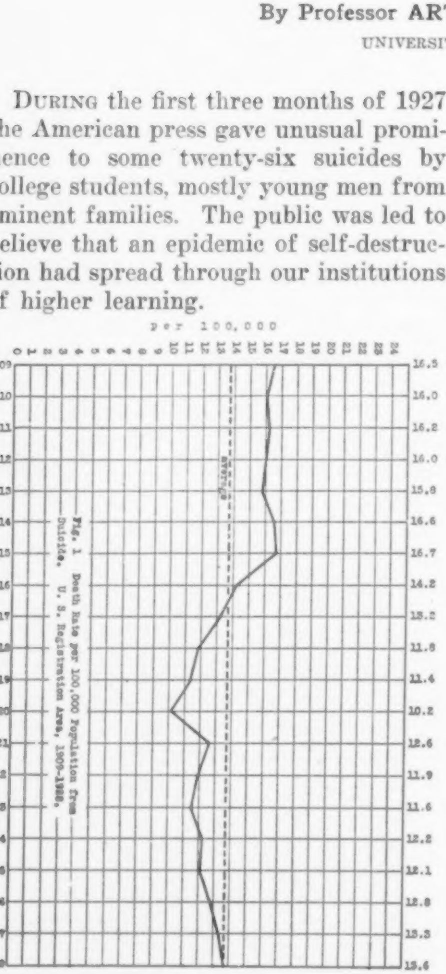

Fig. 1 Death Rate per 100,000 Population from Suicide, U. S. Registration Area, 1909–1928.

Most writers, in discussing the subject, assumed the alleged "wave" to be a fact and undertook to point out its causes and to suggest a cure. A favorite explanation made by certain glib critics of higher education was the "growing cynicism" in college circles and the "substitution of mechanistic philosophies" for the students' religious beliefs.

In the minds of many other observers, however, the question immediately arose as to whether there was a *bona fide* epidemic of suicide among college students, or whether the so-called "wave" was merely an illusion created by the newspapers' treatment of a few spectacular cases. In connection with a report of juvenile suicides in Chicago the present writer pointed out[1] that not until more data were available for the United States as a whole would it be possible to arrive at anything like a reliable conclusion in the matter.

The data necessary to answer this question satisfactorily are now available in the recently published "Mortality Statistics" of the United States Census Bureau, from which the accompanying diagrams have been prepared. Fig. 1 shows the general death rate from suicide per 100,000 population in the United States registration area from 1909 to 1928. The rate for 1927—the year of the alleged suicide "wave"—is 13.3, which, it will be seen, is 0.5 per 100,000 higher than the rate for 1926, and 0.3 per 100,000 lower than the rate for 1928. Moreover, the rate for 1927 is 0.4 per 100,000 lower than the average for the last twenty years for which data are available. It is quite obvious, therefore, that there was no marked increase in the general suicide death rate for 1927 in the United States.

A more precise answer to the question, however, can be found by considering the proportion of suicides in the age-groups from which college enrolments are generally recruited. Fig. 2 shows for each sex the percentage of suicides between fifteen and twenty-four years of age in the United States registration area from 1909 to 1928. It will be noted that the percentage of male suicides in

[1] "Juvenile Suicide," *Social Service Review*, 111: 1, March, 1929.

this age-group was 6.9 in 1927, an increase of only 0.1 per cent. over 1926. For females the percentage was 14.8 in 1927, a decrease of 1.8 over 1926. Moreover, the percentages for both sexes in 1927 are well below the average for the twenty years considered. From this comparison it is quite apparent that there was no increase in the proportion of suicides fifteen to twenty-four years of age in 1927.

It might be objected, however, that since the total number of students in American colleges and universities[2] constitutes only about six per cent. of all young men and young women fifteen to twenty-four years of age[3] in the general population, it would still be possible to have an increase in suicide among college students without such a fact being readily apparent in the totals for this entire age-group. True, but when it is remembered that the total number of all suicides in this age-group in 1927[4] was only 1,225 (742 males, 483 females), it will be seen at once that any significant increase in the number of suicides within this age-range would be readily apparent.

Looking at the matter in still another way: In 1928 there were 1,410 normal schools, colleges, universities and professional schools in the United States. If there had been an average, let us say, of one student suicide to every two such institutions (*i.e.*, a total of 705 suicides), the increase would certainly be apparent in the total number of suicides for this age-group. Even so slight an increase as one suicide to every five institutions (*i.e.*, a total of 282 suicides) would still be apparent by comparison with the preceding years.

In the last analysis, however, the question turns on the definition of the term "wave" or "epidemic." Just how much of an increase in the suicide death rate constitutes an epidemic? While a precise answer to such a question is, of course, impossible, it seems nevertheless reasonable to conclude that anything less than an average of one student suicide to every two institutions of collegiate grade can hardly be called an "epidemic" of suicide.

In conclusion it might be said, however, that while there is no evidence of a suicide "wave" among college students in 1927, the unprecedented increase in college enrolment since the war has nevertheless accentuated the number and variety of other personality problems with which college and university administrations have been forced to deal. Moreover, institutions of higher learning must inevitably pay more and more attention to the mental health of the student if they are to function effectively in preparing him (and her) to cope successfully with the psychological strains of the forties and fifties—critical life-periods during which the hazards of insanity and the neuroses, as well as suicide, are the greatest.

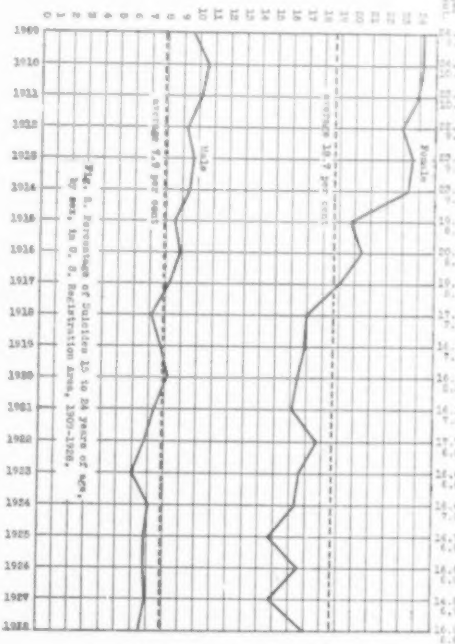

Fig. 2. Percentage of Suicides 15 to 24 years of age, by sex, in U. S. Registration Area, 1909-1928.

[2] 1,216,811 in 1928, according to the Statistical Abstract of the United States 1930.

[3] Estimated at 21,240,000 in 1927.

[4] For 1926 the total was 1,199; for 1928, 1,375. The average for the five years, 1924 to 1928, was 1,191.

THE DEVIL'S WINE

POETIC LICENSE IN AN AGE OF SCIENCE

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I

If any one questions the propriety of mentioning poetry and science in the same breath, then he has only to recall other celebrated affinities to be convinced that politics has no monopoly on the production of strange bedfellows. While the law of Moses forbids the yoking together of the ox and the ass, the lion—when not engaged with the unicorn, the lamb, the lizard or the mouse—has been linked in fable or prophecy with both. Many of these traditional partnerships rest on flimsy grounds at best. A fondness for oysters, it will be recalled, was the bond of fellowship between the walrus and the carpenter. The oysters manifested a reciprocal affection of the highest order—laying down their lives for their friends. What after all is unseemly in the association of the poet and the scientist, those respective laborers in the realms of rhyme and reason?

When the humanist derides the scientist as a man who knows little Latin and less Greek, the scientist accepts the stigma complacently, since it elects him to the honorable company of Shakespeare, and places him one grade above Keats, who knew no Greek at all.

The union of poetry and science, however, is scarcely indicated by the prosy dictionary definition of science as organized knowledge or established facts. Such a definition might plausibly satisfy those benighted individuals who think that the province of science is to design pink bathtubs and develop new lacquers for automobiles, or who conceive of a flight to the poles as a scientific enterprise rather than a sporting adventure or who speak glibly of a blindfolded, scientific test by which a popular idol judges the throat-soothing qualities of a cigarette. It might also be acceptable to a newspaper editor who believes that scientific zeal is measured by the impatience with which one awaits the dawn in order to inspect the record of the nocturnal vagaries of the seismograph. Even a scientist would perhaps prefer it to the poet's definition:

> Science appears but what in truth she is
> Not as our glory and our absolute boast
> But as a succedaneum, and a prop
> To our infirmity.

At least he would wish to reserve judgment until he could get up his little Latin. But if we say with Haldane that "Science is the free activity of man's divine faculties of reason and imagination," it is at once apparent that science approaches the twilight zone of poetry, for the poet is commonly regarded as the chief custodian of the imagination.

The scientist however holds his imagination in check by an appeal to reason and experiment, for none knows better that

> 'Tis Nature you must try conclusions with.

Likewise the fancy of the architect is curbed by the stern necessity that his creations must withstand the force of gravity. But what hand shall bridle the riotous imagination of the poet, "his eye in a fine frenzy rolling"?

> Oh blithe newcomer! I have heard,
> I hear thee and rejoice.

> Oh Cuckoo! shall I call thee bird
> Or but a wandering voice?

Thus William Wordsworth in the intoxication of poetic rapture. Almost as if in answer to prayer, five years later was born a man destined to speak with some authority, although in prose, on the nature of this very phenomenon, be it bird or voice:

> . . . The instinct which leads the cuckoo to lay her eggs in other birds' nests. . . . The young cuckoo, soon after birth has the instinct, the strength and a properly shaped back for ejecting its foster brothers which then perish from cold and hunger. . . . With respect to the means by which this strange and odious instinct was acquired. . . .

Thus Charles Darwin, in a sober report of scientific observations.

Few poets have shared Wordsworth's exalted opinion of the cuckoo. Thus Shakespeare has Portia say:

> He knows me as the blind man knows the cuckoo,
> By the bad voice.

Spenser found the bird appropriate for a disparaging simile:

> So does the Cuckow, when the Mavis sings,
> Begin his witlesse note apace to clatter.

"The Cukkow and the Nightingale," a poem once attributed to Chaucer, alludes to a lover's tokeninge:

> That it were good to hear the nightingale
> Rather than the lewde Cukkow singe.

If the cuckoo as far back as Chaucer's time was regarded by lovers as a bird of ill omen, it has enjoyed even less popularity with husbands ever since the day the crow lost both his white plumage and his musical voice, as related in the Canterbury Tales. Shakespeare, benedick and poet, well understood the sentiment:

> The cuckoo then on every tree
> Mocks married men; for thus sings he
> Cuckoo
> Cuckoo, cuckoo; O word of fear,
> Unpleasing to a married ear!

But for Wordsworth the cuckoo held a peculiar charm, an irresistible fascination. Not content with modernizing The Cukkow and the Nightingale and writing three poems of his own to his "darling of the spring," he indites a fourth in praise of a mechanical counterfeit which he recommends to the sleepless:

> Better provide thee with a cuckoo clock
> For service hung behind thy chamber door.

He writes another beginning,

> Yes, it was the mountain echo,
> Solitary, clear, profound
> Answering to the shouting cuckoo,

and everywhere pays glowing tribute to the haunting Voice—"that wandering voice," "the vagrant voice," "the erratic voice," "the voice of one crying amid the wilderness." The poet likes to think of himself as the voice of one crying in the wilderness, thus identifying poet, bird, and prophet. The scientist dissents somewhat from this conclusion, insisting that a poet who can not distinguish a bird from a voice is more closely related to a cuckoo than to a Messianic prophet.

II

Wordsworth is not alone among the poets in his difficulty with the birds, nor is the cuckoo the only source of his perplexity, for he addresses a linnet as a presiding spirit, a life, a presence, a brother of the dancing leaves. Poe entertains misgivings about the raven:

> Prophet said I, thing of evil,
> Prophet still if bird or devil.

Keats will have it that the nightingale is a winged dryad; while Shelley abandons all restraint in his characterization of the skylark as a blithe spirit, cloud of fire, star of heaven, poet hidden in the light of thought, a high-born maiden, a rose embowered, a glow-worm, golden. But even Shelley's perfervid fancy must yield to Wordsworth's:

I heard the skylark warbling in the sky;
And I bethought me of the playful hare. . . .

This in a poem entitled "Resolution and Independence" but which might better have been called "The precarious state of the leech industry for senile gentlemen."

Other natural objects have been almost as bewildering as the birds:

A nun demure of lowly port;
Or sprightly maiden of Love's court,
In thy simplicity the sport
Of all temptations;
A queen in crown of rubies drest;
A starveling in a scanty vest;
Are all as seems to suit thee best,
Thy appellations.

A little cyclops with one eye

. . . .

A silver shield with boss of gold,

. . . .

I see thee glittering from afar—
And then thou art a pretty star;

This is a conundrum that would baffle a Sherlock Holmes. Just as one has conjured up a picture of a beautiful woman, the vision is shattered by the intelligence that the heroine has but one eye. Then shifting to a monocle, a needle, a spyglass, a kodak,

the
eye
appertaining to
Wilkins Micawber,
"That inward eye
Which is the bliss of solitude,"

we are humiliated to see how far short we have come of a silver shield. Recalling quickly the forms of shields, the scene dissolves and there emerges a star! Defeated, we plead "What does it all mean, poet?" and the poet obligingly answers:

Bright *flower!* for by that name at last
I call thee.

And we learn that we have been reading about a common daisy, "the poet's darling" and the lover's oracle forsooth, but the husbandman's despair. No one would conceive the bard the hero of the story when he writes:

A primrose by a river's brim
A yellow primrose was to him
And it was nothing more.

Even the usually clear-sighted Browning, in poetizing upon some object of devotion which he calls a star, but whose identity we can only surmise, exclaims:

Now it stops like a bird,
Like a flower hangs, furled.

Amid all this confusion of voices, birds, flowers and stars, one lesson seems obvious if poetry is ever to be made intelligible: Poetic license should be dispensed by the State, like a motor or a marriage license. And the aspiring poet should be subjected to a sound scientific course in ornithology and other branches of natural history. Already this need has been partially anticipated. A Johns Hopkins scientist has published a treatise, illustrated with original woodcuts on "How to Tell the Birds from the Flowers." This would be an admirable primer in the proposed Poet's Scientific Series. After the young poet has mastered the rudiments and has learned with some degree of certainty to tell a bird from a flower, he should pursue an advanced course on how to tell a bird from his brothers, the dancing leaves. But a graduate course would be necessary perhaps before he is able to distinguish a bird from a vagrant voice, a winged dryad, or a glow-worm, golden.

Another poet, not quite so sure of his intuitions, finding himself out under the firmament after dusk, reacts to his environment as follows:

Twinkle twinkle little star,
How I wonder what you are!

Now a skeptical scientist, acquainted with the imaginative ways of poets, can assure the curious reader that this pro-

fessed wonder is merely a rhetorical pose, a fine poetic gesture. Suppose he were told that the star is blended hydrogen, helium, calcium, iron and other elements found in the earth, think you he would be appeased? Not he! While he only commits himself to the simile of a diamond, doubtless he has thought also of a bird in repose, a flower hung furled, an ember, a beacon, a firefly, Lucifer, a will o' the wisp, a celestial lanthorn,

> A glow-worm in a dusky nook.

But don't press him too closely. He prefers to *fancy* that the star may be made of green cheese, that it is a divinity or some blushing nymph, translated by a friendly god to shield her from the lust of Apollo, far famed for his devotion to the arts and his pursuit of the humanities! The man who really wonders about the star is the patient astronomer who, armed with his celestial weapons, the telescope, the spectroscope and the photoscope, night after night in his lonely vigils on the mountain top attacks the mystery of the star with the persistence of that legendary army of black and white mice—alternate nights and days—which gnaw continually at the roots of the tree of life.

III

> The lunatic, the lover and the poet
> Are of imagination all compact,

declared one whose reputation as a poet age can not wither nor custom stale. But when the lunatic turns lover and the lover poet, what extravagant flights of the triune imagination may we not expect? For answer we naturally turn to the sonnet, that poetic cameo in which the lover delights to depict his lady fair. Here the poetic fancy flowers as it were in tropical luxuriance. In the few lines which tradition prescribes for the sonnet, the lover-poet can notice only those features of his mistress' beauty comprehended between the golden hair and the alabaster bosom, though he makes a surprisingly complete catalogue of those—the marble brow, the starry eyes, the rosy cheeks, the cherry lips, the pearly teeth, the ivory neck, and—O lover's doom—a heart of stone. True the inventory is not so full as Whitman's:

> Head, neck, hair, ears, drop and tympan of the ears,
> Eyes, eye-fringes, iris of the eye, eyebrows and the waking or sleeping of the lids,
> Mouth, tongue, lips, teeth, roof of the mouth, jaws and the jaw hinges,
> Nose, nostrils of the nose and the partition,
> Cheeks, temples, forehead, chin, throat, back of the neck, neck-slue, etc.

But what the poet's eyes neglect, his nose supplies:

> In Catherine's breath sweet perfume dwells,

asserts Poet Leftly.

> As air perfumed with amber is her breath,

echoes Poet Greene.

> To Arabian odors give thy breathing sweet,

pleads Poet Daniel. But for a breath of such magical virtue that it can impose its essence upon a rosy wreath, we are indebted to the deposition of Ben Jonson:

> But thou thereon didst only breathe
> And sent'st it back to me;
> Since when it grows, and smells, I swear,
> Not of itself but thee!

Are these perchance those "airy nothings" to which the poet gives "A local habitation and a name"? Or is the spurned lover worshiping from afar and ascribing to his beloved's breath the incense which he burns to milady nicotine? On the contrary, the effect is only heightened on closer approach if we may credit the expert testimony of Edmund Spenser, that master sonneteer, caroling in full-throated ecstasy:

Comming to kisse her lyps, (such grace I found,)
Me seemd, I smelt a gardin of sweet flowres,
That dainty odours from them threw around,
For damzels fit to decke their lovers bowres.
Her lips did smell lyke unto Gillyflowers;
Her ruddy cheekes, lyke unto Roses red;
Her snowy browes, lyke budded Bellamoures;
Her lovely eyes, lyke Pincks but newly spred;
Her goodly bosome, lyke a Strawberry bed;
Her neck, lyke to a bounch of Cullambynes;
Her brest, lyke Lillyes, ere theyr leaves be shed;
Her nipples, lyke yong blossomed Jessemynes;
Such fragrant flowers doe give most odourous smell;
But her sweet odour did them all excell.

Any scientist is forced to admire a trained nostril of such selective prowess that, in a moment of delirious rapture, it can disentangle this harmony of perfumes and refer each several odor to its appropriate source. The poem too furnishes one of the few authentic instances of fragrant eyes in the whole realm of scientific literature.

A bundle of myrrh is my well beloved unto me . . .
My beloved is unto me as a cluster of camphire in the vineyards of Engedi,

sang an unknown poet of old Judaea in the Song of Songs. Walt Whitman can find no sweeter fat than sticks to his own bones, and with "barbaric yawp" exults

The scent of these armpits aroma finer than prayer.

If the world were peopled with lovelorn poets, what a dismal place it would be for Lifebuoy and Listerine, those valorous twin knights who rescue fair maidens from the enchantment of the foul and insidious dragon, yclept Malodore! But even in a poet's world there is a ray of hope. For if Juliet "sweetens by her breath the neighbor air," the clown *per contra* must exhale a breath contaminated, witness the report of Casca: "The rabblement hooted and clapped their chapped hands, and threw up their sweaty night-caps, and uttered such a deal of stinking breath because Caesar refused the crown that it had almost choked Caesar; for he swounded and fell down at it." The camaraderie of the highway enabled one of the Canterbury pilgrims, without having recourse to anonymous letters, to apprise the cook of the reason why his social standing had become impaired:

Hold close thy mouth, man, by my faders kin
The devil of helle sette his foot therein,
Thy cursed breath infecte wil us alle
Fy, stinking swyn, fy! evil thee befal!

Even in the sonnet symphony, we detect one discordant note:

And in some perfumes there is more delight
Than in the breath that from my mistress reeks.

We are strangely uncertain as to which most strikes our wonder—the suspicion of halitosis in the beloved, or the germs of skepticism and rational observation discovered in the lover-poet. Can it be that this man Shakespeare had more in common with the scientist than his reputed deficiencies in the classics?

IV

But the poet does not always view the world through the prism of love, which invests ugliness itself with iridescent glory. Although he rarely concerns himself with "the fairy tales of science," there are times when he becomes a moderately reliable observer of Nature:

In the spring a fuller crimson
comes upon the robin's breast
In the spring the wanton lapwing
gets himself another crest;

In the spring a livelier iris
changes on the burnished dove
In the spring a young man's fancy
lightly turns to thoughts of love.

These remarks on the phenomena of the mating season might have been torn bodily from a scientist's notebook. What physicist could improve on the lines

Like as two mirrours, by opposed reflexion,
Doe both expresse the face's first impression?

Chaucer was well versed in the scientific lore of his age. He even composed a treatise on the astrolabe, a knowledge of which rendered him independent of the cuckoo clock in matters respecting the time of day:

Foure of the clokke it was tho, as I gesse:
For eleven foot, or litel more or lesse,
My shadow was at thilke tyme, as there,
Of such feet as my lengthe parted were
In six feet equal of proporcioun.

Your average poet, however, is singularly averse to exact statements of magnitude while the scientist is a wholesale trafficker in relations of quantity no less than in those of quality. Indeed a careful perusal of the poets warrants the conclusion that precision would be as fatal to poetry as to metaphysics. Thus if a poet wished to report the results of a census of the crab population of the inland waters of the North Pacific—taken to decide an idle wager—he would not say directly, like any scientist, that the number was found to be 1.75×10^{10}. But, adjusting his laurel wreath upon his pallid temples, he would deliver himself rather as follows:

Whilom three comrades, zealous in research,
Steeped in mathesis and biology,
Engaged in inconclusive arguments
Anent the number, just and accurate
Of Cancer's teeming pincered progeny—
He of zodiacal demesnes, fourth lord:
Result—a wager, which to resolve,
Computed they with reckoning art divine
A poll of vassals domiciled upon
The far-flung beaches of Vancouver's Sea
And to each living wight the world around
Apportioned ten.

It must have been a poet who pronounced the old Hindu curse upon the perpetrator of what, to an occidental, would appear a trivial offense:

May you be headlong plunged
Into hell's profoundest depths,
Tormented to remain until
The most delicate of maidens
Might wear away the highest peak
In proud Himalaya's range—
Striking it ever so gently
With sheerest silken gauze,
Once every thousand years!

The poet's method at once frees him from the irksome task of consulting authority and places him beyond the reach of the ciphering critic. Thus when the muse inspires the poet to write

His spear—to equal which the tallest pine
Hewn on Norwegian hills to be the mast
Of some great ammiral, were but a wand,

the reader gets the impression of a sizable spear even for an embattled archangel in rebellion. But if one wishes definite dimensions, he will invoke his knowledge of the rule of three in vain. For though a proportion is suggested, all figures—save a figure of speech—are suppressed. The tree compared to the spear is like a wand—compared to what? To an ordinary spear, the tree, or a safety match-stick, hewn on Norwegian hills? Then what is the length of a wand and what the height of the tallest pine in Norway? The poet's position is impregnable.

When Portia says,

For you
I would be trebled twenty times myself;
A thousand times more fair, ten thousand times
More rich,

it might seem that for once the poet had reached the plane of mathematical exactness. But this is only illusion, for he deals in nothing but good round numbers, which incidentally serve the demands of his rhythm. In fact it is a matter of comparative indifference to the poet whether the reading shall be trebled twenty, *i.e.*, 60 times herself, or trebled twenty times, *i.e.*, 3,486,784,401 times herself. Assuming only average endowment for her, the latter figure implies a concentration of merit double the aggre-

gate for the entire population of the globe. While the context seems to point to sixty, what after all are a few billions among poets who hold that

> A mouse is miracle enough to stagger sextillions
> of infidels?

The next line involves a difficulty. We grant that wealth might be appraised and the estate of an heiress enhanced ten-thousand fold. But is it possible that one damsel be a thousand times as fair as another—or twice, or half, or a tithe as fair? Is beauty, in fine, a commodity that is susceptible of being divided into units and magnified in numerical ratio? Is she, like intelligence, under the intrepid assaults of the objective psychologists, destined to lose her traditional place among the imponderables? Will she be dragged to the laboratory to be analyzed, measured and ticketed? We shall have, God save us, medians, quartiles, percentiles. We shall become as familiar with the kalometer[1] as with kilocycles. And to match the moron grade of intelligence, we shall require a hideon rank of pulchritude.

> Behold thou art fair my love
> Behold thou art fair,

sighs the lover of the impending Age of Mensuration. "Just how fair?" drawls the unemotional voice of the esthetical engineer.

> As the lily among the thorns
> So is my beloved among the daughters,

responds the confident lover. The objectivist demands precision—"Have you her score in the Beta Bathing Beach scales?"

> O thou fairest among women!

and the lover hazards his total resources. "Useless for laboratory records," answers the metricologist. Then, glancing at his kalometric chart, he locates the lady in the 43rd percentile, whereupon the lover is advised to refrain from his rhapsodies until he has consulted a competent oculist.

Pope chose verse and even rhyme as the vehicle for his serious philosophical essays, he tells us, no less for its conciseness than for its effectiveness. But few scientific writers have followed his example. A fragmentary instance of an accidentally rhymed and metered statement of a mechanical fact will interest all who have remarked the sag in telephone wires:

> And so no force, however great,
> Can strain a cord, however fine,
> Into a horizontal line
> That shall be absolutely straight.

There is not a superfluous word and no one can impugn the scientific soundness of the lines, still it must be admitted that they contain more truth than poetry.

> "Notation is crystallized thought," said an
> eminent mathematician

is a fair specimen of hexameter verse which carries a profound observation touching mathematical symbolism. The "Song of the Screw," though doubtless composed in a spirit of levity, does not properly belong in a nonsense anthology, notwithstanding its selection by so astute a judge as Carolyn Wells. On the contrary, it is an accurate and far from trivial mathematical essay turned into rhyme, as a single stanza will indicate:

> The pitch of screw, if multiplied
> By angle of rotation,
> Will give the distance it must glide
> In motion of translation.
> Infinite pitch means pure translation,
> And zero pitch means pure rotation.

In his epic of astronomy, Alfred Noyes frequently carries the reader to sublime heights of poetic feeling and dramatic intensity but he celebrates rather the heroes of the science than the science itself. In spite of these examples, there

[1] Greek καλός beautiful + μετρεῖν to measure.

is little reason to suppose that Euclid's Elements, Newton's Principia or Einstein's Relativity would have gained either in clarity or conciseness had the authors in their exposition resorted to

The elegancy, facility and golden cadence of poesy.

V

If poetry be indeed the devil's wine, the secret of the relation between poetry and science may be revealed. For much of science owes its origin to astrology, alchemy, necromancy and other black arts, which a superstitious populace believed were under the direct patronage of the devil, as the legend of Faust attests. Even to-day when "genius" suffices to characterize the art of the poet, the skill of the scientist is heralded on every hand as *wizardry*. But magician or wizard, the scientist yet claims comradeship with the poet in the holy warfare against the ancient despotism of error

And bravely furnished all abroad to fling
The winged shafts of truth.

Poetry has qualities analogous to mathematics, "the queen of sciences":

On poetry and geometric truth,
And their high privilege of lasting life,
From all internal injury exempt,
I mused.

The poet proclaims his devotion to the Spirit of Beauty:

Thus let thy power, which like the truth
Of nature on my passive youth
Descended, to my onward life supply
Its calm—to one who worships thee
And every form containing thee.

But the scientist is no stranger to beauty, he

Anointed priest at Nature's shrine
Chanting the eternal harmonies of the world.

Indeed, according to one poet,

Euclid alone has looked on beauty bare
Let all who prate of beauty hold their peace
And lay them prone upon the earth and cease
To ponder on themselves, the while they stare
At nothing, intricately drawn nowhere
In shapes of shifting lineage.

The scientist does not merely

Spend life's prime in gaining flesh
And giving science one more asteroid

or one more decimal or one more major planet. He is indeed remolding the material world, strewing health, comfort and convenience in his wake, as the scoffers magnanimously concede. But more—to the confusion of the scoffers, who may yet remain to pray—he is also leavening the world of ideas, as the results of his research gain gradual currency. The humblest poet of to-day would repudiate the wisdom of five centuries ago:

For in the sterres clerer than in glas
Is wryten, God wot, who-so coude it rede
The deth of every man, withouten drede.

The scientist holds aloft the banner of truth while the poet keeps pure the fountain springs of beauty. The poet seeks truth in a world of illusion and the scientist finds beauty in the world of reality. Both agree with Keats, if only partially, that

Beauty is truth, truth beauty.

The poet however divines the truth for which the scientist must delve—together firm in the faith that the truth shall make men free.

And Science and her sister Poesy
Shall clothe in light the homes and cities of the free!

SCIENCE SERVICE RADIO TALKS

PRESENTED OVER THE COLUMBIA BROADCASTING SYSTEM

THE GULF STREAM

By H. A. MARMER

ASSISTANT CHIEF, DIVISION OF TIDES AND CURRENTS, U. S. COAST AND GEODETIC SURVEY

ANY long-continued spell of unusual weather along our Atlantic coast is sure to bring out statements that this is due to a shift in the Gulf Stream. A hard winter, a dry summer, a mild winter, a cold summer—no matter what the unusual weather may be—is sure to be blamed on a change in the Gulf Stream. It is therefore not to be wondered at that the springlike weather we have been enjoying this winter along the Atlantic seaboard is being charged to some vagary in the Gulf Stream. Now, what are the facts in the case? Just what do we know about the Gulf Stream? And what are its effects on the weather? It is these questions that we want to consider briefly.

The greater part of our earth is covered by the waters of the oceans, and this great mass of water has a profound influence upon the land on which man lives. To realize how great that influence is, we need merely compare the climate on our Pacific coast with that in the Rocky Mountain states in the same latitude. In fact, the meteorologist recognizes oceanic as contrasting with continental climates. But it is not merely a question whether a given region fronts on the ocean. For there are oceanic regions within the same geographic zones which differ strikingly in climatic conditions. Scandinavia and southeastern Greenland face each other across the Atlantic Ocean, along the same parallels of latitude. Contrast the populous and prosperous lands of the one with the bleak and inhospitable shores of the other! These striking differences are due to winds and ocean currents.

The waters of the sea are never at rest. Wave and tide and current keep them continually in movement. But we must note one decided difference in these movements. In responding to tides and waves the water moves rhythmically, now up and then down, now forward and then backward. But no permanent change in the location of this water is brought about by wave and tide. Ocean currents, on the other hand, transport masses of water continuously in one direction. In doing this, a permanent change in the location of the ocean water takes place. These ocean currents form a mighty system of circulation throughout the seas, carrying the water from one region to another.

The Gulf Stream is the best known and most famous current in this system of oceanic circulation. And it is indeed a stupendous thing. The main branch comes out of the Gulf of Mexico and flows through the Straits of Florida like a mighty river 40 miles wide, 2,000 feet deep and with a velocity at the surface of about four miles an hour. From these data it is easily calculated that the Gulf Stream pours into the sea, through the Straits of Florida, about one hundred billion tons of water each hour.

In these days we have become accustomed to millions and billions; but we may perhaps appreciate better this enormous volume of water which the Gulf Stream carries into the sea by comparing it with the discharge of the

Mississippi River, which drains about 40 per cent. of the area of continental United States. On the average, the Gulf Stream pours into the sea about one thousand times as much water as the Mississippi River. Even when the Mississippi is at extreme flood stage, when its waters are carrying death and destruction in their wake, the Gulf Stream discharges about four hundred times as much water. It has recently been calculated that the Gulf Stream each hour carries twenty-two times as much water into the sea as the total amount of water discharged by all the rivers of the world in a like period of time.

The water which the Gulf Stream pours so prodigally into the sea is of a transparently blue color, and at the surface it is rather warm, having a temperature of about eighty degrees on the average. Below the surface, however, the temperature decreases rapidly and near the bottom it is decidedly cold, registering between 40 and 45 degrees. On issuing out of the Straits of Florida it continues flowing due north for about 200 miles, where it turns easterly somewhat. Here it is joined by another branch of the Gulf Stream known as the Antilles Current. The combined current, still called the Gulf Stream, now flows northeasterly along the south Atlantic states and then across the ocean, bathing the shores of northwestern Europe, and finally is lost in the Arctic seas.

It has been customary to speak of the Gulf Stream as a river in the sea and to picture it on charts with very definite boundaries. Actually this is not the case, for the lateral boundaries are not so well defined, the waters of this current merging more or less gradually with the waters of the open sea. On its western side, however, this merging zone is rather narrow, so that it is separated from the coastal waters of the northeastern states by a zone of rapidly falling temperature, to which the name "cold wall" has been applied. The abrupt change in the waters separated by the cold wall is frequently very striking. On one occasion the U. S. Coast Guard cutter *Tampa* was placed directly across the cold wall. The temperature of the water was then measured. At the bow it was found to be 34 degrees, while at the stern it was 56 degrees, a difference of 22 degrees for the 240-foot length of the ship.

The Gulf Stream loses much of its velocity and temperature in its journey across the Atlantic. Nevertheless, it affects very profoundly the climate of northwestern Europe toward which it flows. How great this influence is becomes evident from the fact that the average temperature for the month of January in northern Norway is 45 degrees higher than the January temperature normal for that latitude. Hammerfest, on the north coast of Norway, in latitude 70° 40′ north—well within the Arctic circle—is an important harbor and fishing center during the winter, while the port of Riga, lying about 800 miles to the south, is obstructed by ice during the winter season.

It is to be noted, however, that the moderating effect of the Gulf Stream on the climate of northwestern Europe is not merely a question of the carrying of relatively warm water to that region. For if there were no agency to transport this warmth on to the land the effect of this warm water would be negligible. It happens, however, that nature has provided an agency for transporting this warmth to the land, this agency being the winds. In winter the winds in northwestern Europe are prevailingly from the southwest. Blowing over the warm waters which the Gulf Stream has brought into this region they carry warm air on to the coast. It is by this means that the heat

exchange takes place in winter between the Gulf Stream and the air of northwestern Europe.

And in this relationship between the Gulf Stream and the wind we find the explanation of why the effect of the Gulf Stream on the climate of the Atlantic coast of the United States is negligible. For, aside from latitude, our climate depends mostly on the direction from which the wind comes and the force with which it blows. In winter the wind along the northeastern coast of the United States is prevailingly from the northwest, that is, from the land. Hence the warm waters of the Gulf Stream, lying several hundred miles offshore, can not moderate the climate of our northeastern states. If the winter winds along our Atlantic seaboard could be made to blow from the east and southeast, there is every reason to believe that the climate of our northeastern states would be much milder. And this would result not because the Gulf Stream moved nearer the coast, but because the winds would carry on to the land the warmth of the waters of this stream.

From time to time schemes are seriously proposed for changing the course of the Gulf Stream with the view of moderating the climate along our northeastern coast. Quite apart from the question whether the proposed schemes are adequate to bring about a change in the course of this mighty current, it is clear that such schemes are absurd. For even if the Gulf Stream were brought nearer our shores, the climate would be moderated only if the winter winds were made to blow towards the land. Indeed, there are good reasons for believing that if the Gulf Stream were to shift closer to our coast, the climate of our northeastern states would become more extreme rather than moderated—colder and more stormy in winter, and hotter and more humid in summer. For with warmer air near the coast in winter, a greater flow of cold air from the northwest would result, bringing severer storms and colder weather. In summer, the winds along the coast are more or less sea breezes, bringing the cooler air from the sea to moderate the heat. With warmer air near the shore the sea breezes would become weaker and less frequent and thus give wider scope for the hot land winds.

In connection with the question whether there has been any change in the Gulf Stream, it is of advantage to consider briefly the causes that give rise to this current. Primarily, the Gulf Stream is due to the trade winds. These winds bring about a westerly flow of the waters in the equatorial regions of the Atlantic Ocean. This flow of equatorial water on striking the coast of South America is deflected. The greater part flows to the northwest into the Caribbean Sea and then into the Gulf of Mexico from which it issues as the Gulf Stream into the Straits of Florida. The course of the Gulf Stream is thus determined by the force and direction of the winds, by the direction of the coast line, and by the configuration of the ocean bottom over which it flows.

Now if the question is asked, Has the Gulf Stream changed? the oceanographer hesitates somewhat, and asks in turn: Just what do you mean by a change in the Gulf Stream? If you mean a decided and permanent change, then the answer is unquestionably No. For a permanent change in so mighty a current can arise only from a permanent change in the force or direction of the prevailing winds, or from extensive changes in the direction of the coast line or the configuration of the ocean bottom. Since no such changes in these features have been observed, it is highly improbable that any decided change in the Gulf Stream has taken place.

But if by changes in the Gulf Stream are meant temporary changes, or more

accurately, fluctuations in the velocity, temperature and location of its waters, the answer must be Yes. From the nature of the case it is obvious that heavy winds, blowing with or against the Gulf Stream, will accelerate or retard its velocity. Furthermore, heavy winds blowing across the Gulf Stream will carry its waters out of their normal channel either nearer to the coast or further away. Variations in barometric pressure likewise will bring about fluctuations in the movement of this stream. Seasonal variations of temperature in the regions through which it flows will be reflected in somewhat similar seasonal variations in the temperature of its waters. Fluctuations in the Gulf Stream will also arise as a result of fluctuations in the currents which feed it, or which, like the Labrador Current, come into conflict with it. Such fluctuations have, in fact, been observed. But these fluctuations are temporary and fleeting, being brought about by temporary changes in wind and weather.

Now it may be asked, are the fluctuations in the Gulf Stream reflected by changes in the weather? Since meteorological conditions are affected by temperature changes in the ocean, fluctuations in the Gulf Stream undoubtedly affect the weather. But the Gulf Stream is only a minor factor in the climate of the United States; and hence the effects of its fluctuations on our weather are so small as to be negligible. While the fluctuations of the Gulf Stream are only of minor importance in regard to the weather, they affect very profoundly the conditions for life in the ocean. It is as an oceanic feature that the Gulf Stream bulks large. Oceanographers are generally not given to rhetorical flourishes; yet one of them, after spending several years in investigating the Gulf Stream, described it as "the grandest and most mighty terrestrial phenomenon."

NEW DISCOVERIES IN OLD PERSIA

By C. ROSS SMITH

THE UNIVERSITY MUSEUM, UNIVERSITY OF PENNSYLVANIA

THE joint expedition of the University Museum and the Pennsylvania Museum of Art, engaged during the past season in excavation work at Tepe Hissar, a site about seven miles from the city of Damghan in northwestern Persia, has made two discoveries of great archeological importance. The expedition, under the direction of Dr. Erich Schmidt, of the University Museum, first unearthed a cemetery believed to be more than four thousand years of age. Shortly after this they discovered a Persian palace of the Sasanian dynasty, dating from the fourth century of our era. It is of the cemetery that I wish to speak first. Scores of graves were opened, revealing the remains of a people who lived at Tepe Hissar in about 2000 B. C. Their racial origin is unknown, but it is possible that they may form a connecting link between the civilizations of India and Mesopotamia. I can do no better than to describe in Dr. Schmidt's own words the extraordinary sight that met the eyes of the excavators.

"It is an awe-inspiring thing," he says, "to look upon the remains of a hundred people, dead ages ago, exposed with their mortuary equipment to the sunlight in one great necropolis. Thus we found them in the main mound at Tepe Hissar. Altogether about two hundred graves of the last Tepe Hissar people have been unearthed, and one can imagine the wealth of information and

the beautiful objects derived from them. There were remains of little children, with their miniature dishes, as well as those of men and women, with cups, bowls and pitchers of the attractive gray ware of the period. Many were found with strings of beads still attached to their necks, and bracelets, anklets and finger rings of copper clinging to their bones. It is with admiration that the hand of the archeologist touches the translucent or banded alabaster vessels, and the burnished gray or black pottery, much of it without a crack or a scratch, emerging from these burials. The position of every bone and every object is accurately surveyed.

"One of the most interesting things that we found was a little girl's grave. There had been buried with her lapis lazuli beads, gold ear pendants, onyx beads and some small figurines carved in the shape of sheep and oxen. Some plain silver pins and six little silver cups completed the child's equipment for the other world. In one of the graves were found the remains of a warrior, dead almost four thousand years. Beside him were his weapons—a bident, or long two-pronged fork, a dagger, a battle axe and a helmet. A silver pitcher, covered with the purplish gray patina that is acquired with age, lay close to his head. The left hand held two gold-coated rings and a string of lapis lazuli and onyx beads. The results of our first season's work on the Tepe Hissar cemetery are of an intensely interesting and important nature. The dead of Tepe Hissar and their mortuary equipment illuminate an entirely new phase of human culture in this region of the world."

While excavation work was being continued on the cemetery the attention of Dr. Schmidt was drawn to a promising looking mound in the neighborhood. A preliminary investigation brought up some beautiful stucco ornaments in sufficient quantity to indicate the presence of an important structure. The finds warranted the concentration of all the expedition's forces on the new site and in a short time a large area was cleared. Dr. Schmidt's idea proved to be a happy one, for on the completion of the work there was revealed an admirably planned palace structure with a central colonnaded hall about a hundred feet long with a series of chambers and rooms extending diagonally on either side. It is believed that this palace of the Sasanian dynasty of Persia was occupied about 300 A. D.

The building was constructed of burnt and sun-baked brick, the latter having, of course, pretty much disappeared with time. The main hall was probably vaulted and carried parallel rows of eight columns, four on each side, each column being nearly six feet in diameter and set in from the side wall, thus providing aisles on either side approximtely six feet in width. The entrance to the palace must originally have been impressively beautiful. The portal, with its triple arched recess, was flanked by large columns, apparently with life-sized lions as guardian deities. The columns were covered to a height of six feet with richly modelled stucco ornament. The arches, door frames, friezes and cornices were equally rich. At the corners seem to have been small towers or turrets, for observation or defense.

The interior was lavishly enriched by stucco ornament of splendid quality, giving us a few patterns somewhat new in the history of Sassanian ornament. The walls were evidently covered with rich mural paintings in purplish red, blue, carmine, white and ochre. A group of fragments show a horseman at full gallop, recalling many of those found on Sasanian plates. Some of the friezes were composed of rows of plaques containing boars' heads—an animal which the Sasanians loved to hunt.

The boars' heads closely resemble those of a stucco panel recovered from the remnants of a Sasanian palace near Varamin, Persia, in 1920, and now housed in the Pennsylvania Museum of Art.

Other plaques contain portrait figures of a smiling Sasanian queen or princess wearing a triple pearl necklace, the hair being bound with a simple fillet. These plaques were framed in a rich four-lobed leaf of a Greek character, a common ornament in the West down to medieval times. Some of the plaques are marked with Sasanian symbols which have not yet been identified, but which may throw an important light on the date of the building. The ornaments of some of the vaulted arches are particularly beautiful and clearly indicate unsuspected origins of certain Islamic patterns that were common in sixteenth century Persian carpets. The exact nature of these patterns has hitherto been obscure.

Near the palace Dr. Schmidt found a pavilion with slender columns, a type of structure that has been in favor in Persian gardens for centuries. It had been thought that these garden pavilions were a Chinese importation of medieval times, but Dr. Schmidt's finds, which tally well with what we know of the Sasanian interest in gardens, would seem to give independence to Persia in this regard.

The artistic remains of the Sasanian dynasty, a period which ranged from 220 to 650 A. D., are scanty but impressive. Prior to the finds of last summer not much had been found representative of one of the Persian empire's great dynasties. A few textiles, simple but rich in color; some bronze vessels; some silver plates with figures of uncommon force and splendor and the ruins of a few mighty monuments with colossal brick vaults are the witnesses of one of Persia's greatest periods and of an artistic epoch that influenced the whole world. For its own quality and because of what it has contributed, particularly to Romanesque and Gothic architecture, more knowledge about this period has long been sought.

The recent finds of Dr. Schmidt at Damghan give us further assurance that in architectural ornament the Sasanians were capable of achievements of the highest order. It is too early as yet to assign a definite date to the palace. When they have been finally analyzed, some badly corroded coins will probably decide the question. So far, there are reasons for thinking that the palace may date from the early part of the fourth century or the late part of the third. The palace has historical as well as artistic interest. Hitherto important Sasanian structures have all been found in the south or in the west. From this it was concluded that the Sasanian culture was much less developed in the north and in the east. The recent finds show a rich sophisticated architecture much farther to the northeast than anything previously known.

While the palace, so far as it has been uncovered, does not seem to vie in size with the colossal structures of Ctesiphon and Chahar Takun, nevertheless its existence is a proof that Damghan was an important Sasanian center occupied by some one of high rank. We have every assurance that the work at Damghan will be continued next season.

THE RESEARCH WORK OF THE UNITED STATES PUBLIC HEALTH SERVICE

By R. C. WILLIAMS, B.S., M.D.

ASSISTANT SURGEON GENERAL, U. S. PUBLIC HEALTH SERVICE

PRESIDENT HOOVER has said: "In public health the discoveries of science have opened a new era. Many sections of our country and many groups of our citizens suffer from diseases the eradication of which are mere matters of administration and moderate expenditure. Public health service should be as fully organized and as universally incorporated in our governmental system as is public education. The returns are a thousand fold in economic benefits and infinitely more in reduction of suffering and promotion of human happiness."

It is generally admitted that one of the basic necessities of national life is proper protection of the public health. To some this is merely a dictum which they concede to be true in a vague, general way, but about which they have never thought in concrete terms, and towards which they feel no sense of personal interest or responsibility. To others of us, particularly public-health workers, the protection of the public health is so interwoven with national prosperity and happiness, is so closely correlated with continued national existence and development, is a matter of such vital concern to every citizen in the land—quite as much as the income tax or the tariff—that we feel that every one should have some idea about what the protection of the public health means, what it ought to do and what research is being conducted still further to safeguard the health of all the people.

Generally speaking, there are four agencies which are concerned with the protection of the public health. We have, first, the private citizen, who owes it both to the community and to himself to keep himself and his family in a continuous condition of good health and so to order his acts that he will not willingly endanger the life or health of others through spreading disease. This sense of personal responsibility toward the public health is one of the qualities of individual citizenship that should be fostered by every means at our command, for it is this sense of personal initiative and responsibility which is one of the basic elements of greatness of the American nation and which will make possible the development in this country of the most effective system possible of public-health protection.

The next agency is the local community, which performs, in a collective way, for the citizen those things for the protection of the public health that he can not efficiently undertake for himself; for instance, the provision of a pure water supply, the prevention of the spread of communicable disease, the prevention of the contamination of milk and other foods and similar health safeguards.

The next agency we have is the state department of health, which performs for the communities, in a collective way, health activities which the communities themselves could not or should not undertake.

Last of all is the federal government, which, through its health agencies, undertakes for the states health activities which it would be wasteful, unwise or impracticable for them to perform for themselves. We have here, then, a continuous chain of health agencies stretching all the way from the private citizen to the national government, each

in a way autonomous, yet correlated, each having its own sphere of responsibilities and activities, each contributing its share to health protection, and each supplementing but not supplanting the other.

The U. S. Public Health Service is charged by law with a variety of functions, among which may be mentioned the protection of the United States from the introduction of disease from without, the prevention of interstate spread of disease, the suppression of epidemics, cooperation with state and local health authorities in public health matters, the supervision and control of biologic products, such as sera, vaccines and antitoxins, and investigations of the diseases of man and conditions influencing their propagation and spread.

It is necessary not only to fight epidemics and diseases while they are actually present, but also to devise means of preventing them. Granted that the necessity for research exists, the question then presents itself as to whether the government should engage in research. Experience and reason both give an affirmative answer. While it is true that in the United States, as elsewhere, a large amount of research connected with the safeguarding of public health is carried on by private agencies, there are, nevertheless, compelling reasons why the government itself should be represented in this field.

A careful analysis will show that by far the greater part of the research work conducted under the auspices of private agencies is directed to the solution of problems that are almost entirely local, or problems pertaining to curative rather than preventive medicine. On the other hand, the government, being interested in the welfare of the entire population, concentrates its efforts upon problems affecting large groups and upon preventive rather than curative methods. The government also has a duty to perform in checking up on the results of outside research to determine whether or not much of this information can be recommended for general guidance and in verifying scientific information for administrative purposes. Then, too, there are certain problems which no private agency is equipped to solve. These are problems requiring observations widely distributed in a geographic sense and, also, the problems which can be solved only by the concentration of many different research activities working in cooperation and simultaneously. In addition to all of these reasons, there is, of course, the government's obligation to promote the welfare of the people, an obligation which is not shared by outside private agencies which, properly enough, have their own ends in view in many of their activities.

Many contributions to modern medicine and hygiene have been made by the research workers of the Public Health Service. Observations made by a Service officer as to the incubation period of yellow fever aided materially in the discovery of the method of transmission of that disease. Studies made by the investigators of the Service have shown that pellagra is a disease caused by improper diet, and that the prevention and the cure of the disease lie in the eating of a well-balanced diet. The identification of the American species of hookworm as the cause of a wide-spread anemia was accomplished by an officer of the Public Health Service, and has resulted in a notable diminution of the prevalence of this disease. The cause, means of transmission and prevention of tularemia, a disease endemic in certain sections of the United States, were discovered by an officer of the Public Health Service. A worker of this national health organization has shown the similarity of the organism which causes undulant fever in human beings and

contagious abortion in cattle. Undulant fever is increasingly being recognized as a cause of human illness.

An officer of the Service has developed a vaccine for the prevention of Rocky Mountain spotted fever, a highly fatal disease. Within the past few months, announcement has been made of observations by research workers of the Service which prove the flea to be a mode of spread of endemic typhus fever, a recently recognized public health problem in this country. In connection with these studies, it has also recently been found by Service officers that Rocky Mountain spotted fever, formerly thought to be confined to the Rocky Mountain region, has probably existed along the east coast of the United States for at least a score of years. Cases formerly thought to be a severe type of typhus fever have now been identified as Rocky Mountain spotted fever of the eastern type. Workers of the Public Health Service were the first to show that serum from an abortive case of infantile paralysis neutralized the virus of that disease. This indicated more clearly than had been shown before by clinical and epidemiological studies that paralysis is not a necessary part of the disease.

These contributions of the Public Health Service to the knowledge of preventive medicine have not been made without consequent loss of health and life among the army of germ-fighters. This research salient in the battle line of public health has its casualty list. Some have fallen in the attack on yellow fever; typhoid fever and Rocky Mountain spotted fever have claimed their share; and psittacosis—the most recent cause of casualty—has taken its toll; while tularemia and undulant fever have been important causes of disability among these soldiers of science who volunteer to fight, often against an unseen foe.

The studies now being conducted by the Public Health Service relating to the various problems affecting public health are numerous. They include studies on cancer, leprosy, malaria, Rocky Mountain spotted fever, pellagra, trachoma, tularemia, meningitis, infantile paralysis, heart disease, undulant fever, typhus fever, child hygiene, industrial hygiene, milk sanitation, stream pollution, morbidity, water purification, and a number of others.

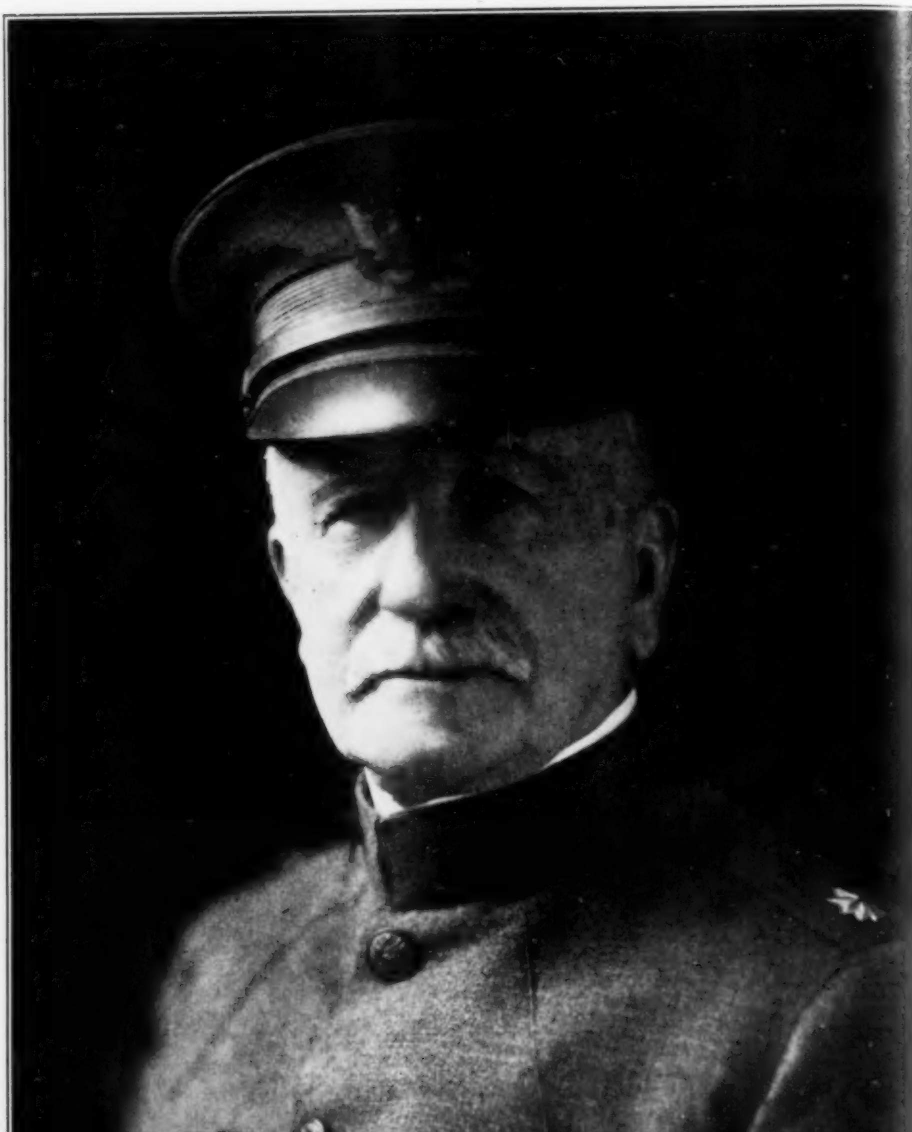
A recent act of Congress has created under the Public Health Service the National Institute of Health. In reality, the Hygienic Laboratory, which has been conducting laboratory research since 1901, has become The National Institute of Health, which, with greatly enlarged facilities, will be devoted to investigations of the underlying problems, not only of the communicable diseases, but also of degenerative diseases and environmental conditions affecting health. In the aid of research work, this act authorized the Secretary of the Treasury to accept gifts to be held in trust and to be used for the purposes mentioned, the expenditures to be safeguarded in all respects as are other governmental funds. These gifts may also be used for the establishment of fellowships.

The necessity for research work in the field of public health is fully as important to-day as it was twenty-five years ago, if not more so. With the progress of public health during the past century, there has been much improvement in conditions of general environment, such as water supplies, milk, food, housing and related matters, although there is still need for constant vigilance in the application of modern sanitary knowledge and in research involving new methods.

With the continued increase of the population in many sections, there are still many important problems relating to sewage disposal and water supplies

which must be considered. With the improvement of general environmental conditions, there is need for more emphasis upon the environment of the individual as relates to occupation, personal health, and similar matters. Although there have been many important discoveries relating to the preservation of health and the prevention of disease, there still remain many problems to be solved. Research work in medical and public health fields is becoming increasingly difficult, and requires specialized training and intense application. The so-called degenerative diseases are among the more important causes of death. Studies in this field offer opportunities for important advances. There are problems relating to a number of the communicable diseases which are yet to be solved, among which are whooping-cough, measles, scarlet fever and meningitis. In a special group may be mentioned the virus diseases, such as infantile paralysis and influenza. Perhaps some new developments in the field of bacteriology will place within our hands the necessary weapons with which we will be able effectively to cope with these dread diseases.

One of the important needs of the present day in public health is the further development of facilities for the application of known facts relating to the prevention of disease. This means a strengthening and development of health service as rendered by local, state and federal health officials. Important scientific discoveries relating to the prevention of disease may be made, but unless such discoveries are applied, little benefit results from them. This in itself is an argument for research in methods of applying sanitary knowledge and in administration, since effective means of employing academic information are still imperfectly known. As a matter of fact, one of our investigations at the present time is a study of public health practices from the points of view of their intrinsic value and the economy and effectiveness of their application.



DR. WILLIAM WILLIAMS KEEN

THE DISTINGUISHED SURGEON OF PHILADELPHIA, SINCE 1889 PROFESSOR AND EMERITUS PROFESSOR IN THE JEFFERSON MEDICAL COLLEGE, WHO DIED ON JUNE 7, AT THE AGE OF NINETY-FIVE YEARS.

THE PROGRESS OF SCIENCE

THE ANNUAL MEETING OF THE NATIONAL ACADEMY OF SCIENCES

THE National Academy of Sciences held its annual meeting this year from April 25 to 27 in Washington. Its meetings are devoted largely to the presentation of papers of a scientific nature from different fields of science. The scientific sessions are open to the public and afford the visitor opportunity to become familiar with recent advances in certain fields of science. Thirty-five papers were presented at the annual meeting; their distribution among the sciences was as follows: astronomy, 4; chemistry, 8; physics, 6; mathematics, 1; geology, 3; engineering, 2; genetics, 4; physiology, 3, and botany, 4. Many of the papers were technical in character and not easy to follow in detail in spite of the effort which each speaker made to present his subject clearly and simply. Subjects of general interest were considered in the following papers: The cure of drug addicts, by Drs. Bancroft, Gutsell and Rutzler; Experiments on the mode of infection and means of prevention of epidemic poliomyelitis, by Dr. Simon Flexner, of the Rockefeller Institute for Medical Research; Critical geologic features in the Hoover Dam site, by Dr. C. P. Berkey, of Columbia University; Cosmic ray energies and their bearing on the photon and neutron hypotheses, by Drs. Millikan and Anderson; A deaf speaker, by Dr. F. Bedell, of Cornell University; Projection of motion pictures in relief—an experimental realization, by Dr. H. E. Ives, of the Bell Telephone Laboratories.

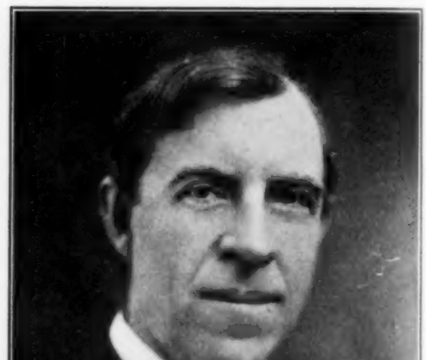
On Monday evening, April 25, the one hundredth anniversary of the electrical discoveries of Joseph Henry was celebrated. At this meeting Professor W. F. Magie, of Princeton University, spoke on Henry as a physicist; Mr. Bancroft Gherardi, of the Bell Telephone Company, on Henry as an electrical pioneer, and Dr. C. G. Abbot, secretary of the Smithsonian Institution, on Henry as an administrator. There was also a special exhibition of Joseph Henry's electrical apparatus, including induction coils, batteries, motor models, and the "Yale" magnet loaned by the Smithsonian Institution; a replica of the Henry electrical engine and his magnet for ringing a bell, loaned by the Albany Institute, through the Bell Telephone Laboratories; these pieces were in operation in the exhibition halls during the academy meetings. Other special apparatus shown during the meetings were: The "deaf speaker" of Professor Bedell for the use of persons with defective hearing in listening to radio programs; Dr. H. E. Ives gave a demonstration of an apparatus to illustrate his paper on the projection of motion pictures in relief; Dr. Abbot demonstrated the "periodometer" for detecting and evaluating regular periodicities in long series of observations, such as the values of the constant of solar radiation.

On Tuesday afternoon the session was given over to a symposium on climatic factors. In 1930 the Secretary of the Navy requested the National Academy of Sciences to consider and to report upon the different methods of long-range weather forecasting and the scientific bases for these methods. A committee was appointed, with Dr. J. C. Merriam, chairman, to examine into the subject. The committee realized that a knowledge of the variation, with time, of the factors responsible for the fluctuations in the weather is an essential preliminary to an analysis of the problem. In the symposium on climatic cycles the possibility of a periodic or cyclic element in earth climate was discussed from different

DR. MARSTON MORSE
PROFESSOR OF MATHEMATICS AT HARVARD UNIVERSITY

DR. JOHN C. SLATER
PROFESSOR OF PHYSICS AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

DR. RAYMOND T. BIRGE
PROFESSOR OF PHYSICS AT THE UNIVERSITY OF CALIFORNIA



DR. F. K. RICHTMYER
PROFESSOR OF PHYSICS AT CORNELL UNIVERSITY

DR. ROBERT J. TRUMPLER
ASTRONOMER OF THE LICK OBSERVATORY

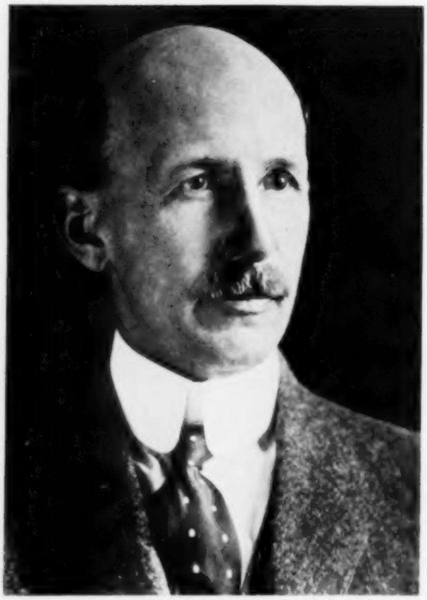
view-points. Dr. Merriam in his introductory statement emphasized the fact that "in studies of periodicity we are concerned with the factors which have to do with reception of radiation coming principally from the sun, as also with the nature of fluctuations in the source of that radiation. This symposium represents largely an attempt to present from several points of view the facts regarding radiation and its influence on the earth. The presence of periodicities or cyclic movements would not by themselves guarantee the nature of what is commonly called weather. Other factors related to varying local conditions may affect the swing of the general influences in such way as to erase their effect at least temporarily." Dr. A. E. Douglass, director of Steward Observatory at the University of Arizona, spoke on climatic cycles as illustrated in tree rings. He showed the influence of climate upon tree growth; and conversely he emphasized the significance of tree rings in registering seasonal fluctuations in climate. Dr. C. G. Abbot summarized the observations on the variations in the intensity of solar radiation and showed that changes in terrestrial temperatures are largely governed by variations in solar radiation, thus indicating that long-period forecasts of weather may be based on periodic variations in the value of the solar constant of radiation. The paper by Drs. Adams and Nicholson, of Mt. Wilson Observatory, on the nature of the solar cycle summarized the evidence on the changes in the physical aspect of the surface of the sun as a result of changes in its activity. Measured by this method, the cycle of sun-spot activity, which is most nearly periodic and of the largest amplitude, is of about 11 years' duration; but it varies between 6 and 14 years and its amplitude, by 50 per cent. of the average value. Dr. I. Bowman, of the American Geographical Society, spoke on the correlation of sedi-

DR. J. B. WHITEHEAD
DEAN OF THE SCHOOL OF ENGINEERING,
THE JOHNS HOPKINS UNIVERSITY

mentary and climatic records, emphasizing the work of De Geer in Sweden and of Antevs in America on the banded clays of late glacial origin. Thus far no satisfactory correlation between these "varves" and tree rings has been made. He pointed out the need for a thorough study of the sedimentary process and its correlation with rainfall, temperature and stream discharge. From the discussion which followed the presentation of these papers it was evident that more data are needed for a satisfactory basis on which to develop adequate methods for long-range weather forecasting.

At the annual business meeting of the academy Dr. Arthur Keith, of the U. S. Geological Survey, was elected treasurer for the period July 1, 1932, to July 1, 1936. Two new members of the council were elected:

Ross G. Harrison, Yale University.
Henry Norris Russell, Princeton University.



DR. WALTER C. MENDENHALL
DIRECTOR OF THE U. S. GEOLOGICAL SURVEY

DR. DOUGLAS JOHNSON
PROFESSOR OF PHYSIOGRAPHY AT COLUMBIA UNIVERSITY

DR. L. O. KUNKEL
PATHOLOGIST AT THE BOYCE THOMPSON INSTITUTE FOR PLANT RESEARCH

Four foreign associates were elected:

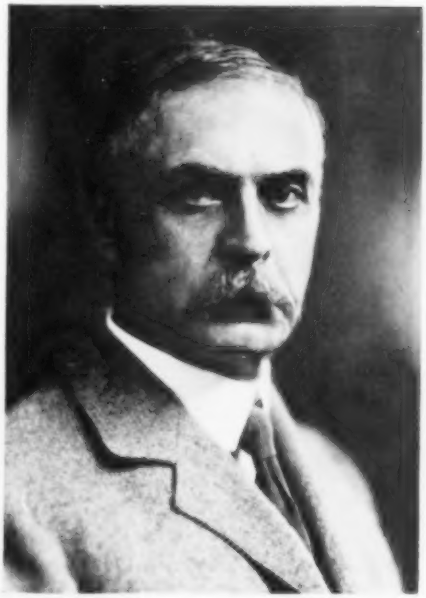
Karl E. von Goebel, botanist, Munich, Germany.
Fritz Haber, chemist, Berlin, Germany.
Marchese Marconi, electrical engineer, Italy.
Heinrich Wieland, chemist, Munich, Germany.

Fifteen new members were elected (the limit permitted by the rules):

Raymond T. Birge, physicist, University of California.
Edwin G. Boring, psychologist, Harvard University.
Samuel R. Detwiler, anatomist, Columbia University.

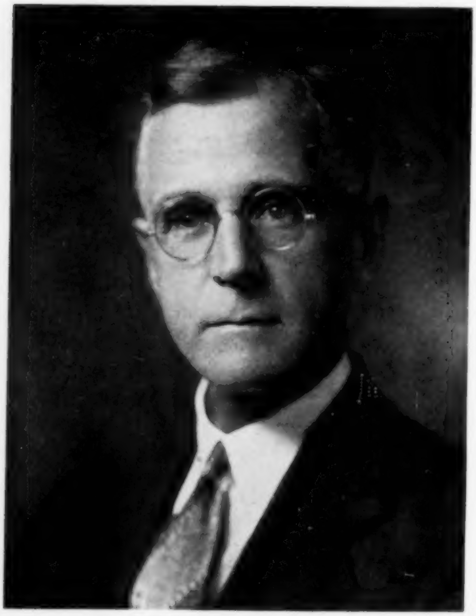
DR. S. R. DETWILER
PROFESSOR OF ANATOMY AT COLUMBIA UNIVERSITY

Walter A. Jacobs, chemotherapist, Rockefeller Institute for Medical Research.
Douglas W. Johnson, geologist, Columbia University.
Louis O. Kunkel, plant pathologist, Boyce Thompson Institute, Yonkers, N. Y.
Karl Landsteiner, pathologist, Rockefeller Institute for Medical Research.
Walter C. Mendenhall, geologist, U. S. Geological Survey.
(Harold) Marston Morse, mathematician, Harvard University.



DR. KARL LANDSTEINER
MEMBER OF THE ROCKEFELLER INSTITUTE

DR. WALTER A. JACOBS
MEMBER OF THE ROCKEFELLER INSTITUTE



DR. JOHN R. SWANTON
ETHNOLOGIST AT THE SMITHSONIAN INSTITUTION

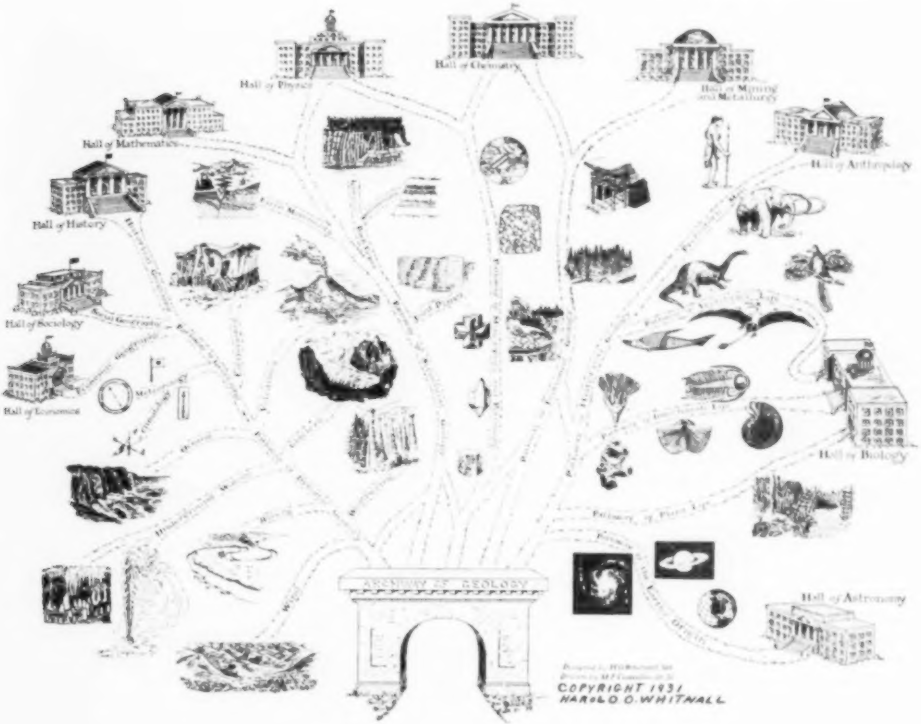
Floyd K. Richtmyer, physicist, Cornell University.
John C. Slater, physicist, Massachusetts Institute of Technology.
John R. Swanton, anthropologist, Bureau of American Ethnology.
Robert J. Trumpler, astronomer, Lick Observatory.
Edward W. Washburn, chemist, Bureau of Standards.
John B. Whitehead, electrical engineer, Johns Hopkins University.

Two medals were awarded at the annual dinner on April 26: The Mary Clark Thompson Medal, with honorarium, to Dr. David White, U. S. Geological Survey, for his outstanding researches in paleontology; the presentation address was made by Professor W. B. Scott, of Princeton University. The Public Welfare Medal of the Marcellus Hartley Fund was awarded a year ago to Dr. Wickliffe Rose, at that time director of the International Health Board of the Rockefeller Foundation and president of the General Education Board. Dr. Rose died in September, 1931. The medal was received by his son, H. Wickliffe Rose. The presentation address was made by Dr. Simon Flexner, of the Rockefeller Institute for Medical Research.

The present membership of the academy is 270; the membership is limited to 300. The foreign associates number 47; the limit is fifty. Attending the annual meeting were 112 members. The average attendance at the scientific sessions was 335. The autumn meeting of the academy will be held this year from November 14 to 16, at Ann Arbor, Michigan.

F. E. WRIGHT
Home Secretary

DR. EDWIN G. BORING
PROFESSOR OF PSYCHOLOGY AT HARVARD UNIVERSITY



THE FIELD OF GEOLOGY

THE accompanying pictographic map of the Field of Geology was designed for a survey course in physical science for freshmen at Colgate University. The divergent pathways show the many ramifications of earth science and the hall of knowledge to which each pathway leads.

All the paths show cross connections. To one versed in the science of geology, these cross paths could be greatly multiplied, but to the beginner, it is sufficient to indicate that all the highways are accessible to one another. Furthermore, greater detail would show that the various halls, to which the main paths lead, could also be connected by labyrinthine passages.

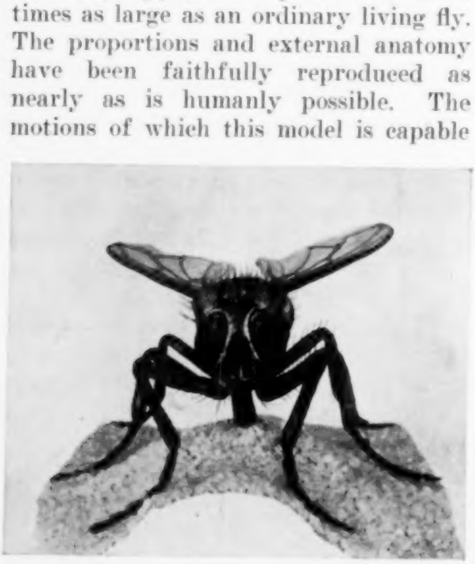
Aside from the pictorial designs which suggest the varied aspects of geological knowledge, there are mental and moral values which can not be expressed by drawing or diagram. Geology feeds the mind wherever our travels lead us, giving pleasure through the enjoyment of natural scenery, arousing the finer emotions. To philosophic minds, it supplies a vast reservoir from which may be drawn practical wisdom, fortitude and contemplation of that paradoxical thought that, although man is an insignificant organism on the mote in space which we call the earth, he is able to perceive the universe.

HAROLD O. WHITNALL
DEPARTMENT OF GEOLOGY,
COLGATE UNIVERSITY

A MECHANICAL HOUSE FLY

METHODS of visual instruction in scientific facts are constantly improving, yet we are still considerably behind the commercial world in this particular. Who has not paused in rapt attention before a shop window in which a wax figure of a man goes through the motions of adjusting his cravat or makes some other simple motions common to all of us. The business man has learned that it is a sure way of attracting the attention of the crowd. Perhaps it is the survival of a very primitive instinct that automatically arrests our attention at the sight of motion. Be that as it may, it is a fact that the eye will travel rapidly over a score or more of inanimate objects to come to rest instantly upon the slightest indication of motion among those objects.

For some time now the United States Department of Agriculture has been making its exhibits more attractive by including models of animals which have some degree of motion. The latest innovation of this kind is a huge mechanical house fly approximately four thousand times as large as an ordinary living fly. The proportions and external anatomy have been faithfully reproduced as nearly as is humanly possible. The motions of which this model is capable



are limited to the raising and lowering of the proboscis upon a pile of sugar as in the act of feeding, and a slight raising and lowering of the wings. The motions are coordinated so that immediately after the proboscis is raised from the sugar the tips of the wings rise slightly and settle back to normal position. To one watching this action the illusion is strong that the lifting of the wings denotes real satisfaction with the taste of the sugar upon the part of the automaton.

The following legend is attached to this exhibit:

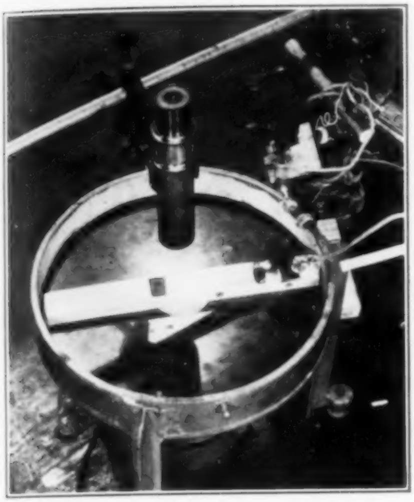
FLIES ARE DANGEROUS

The bottom of a fly's foot is soft like a cushion and there are numerous hairs on the legs. Therefore, when a fly walks over infected material of any kind thousands of bacteria become attached to the feet and legs. When the fly goes from this infected or disease-laden material to your dining table the bacteria (germs) may very readily be rubbed off in the sugar bowl, butter dish, or your child's glass of milk.

The lesson the legend conveys becomes a very forceful one when the spectator studies this huge hairy object and imagines it tracking about and nosing into the food upon the dining table. The mechanical fly is sent out by the Department of Agriculture on state fair circuits and attracts a great deal of attention wherever it is exhibited.

J. L. WEBB

A CENTRIFUGE-MICROSCOPE



THE NEW CENTRIFUGE-MICROSCOPE
THIS DEVICE PERMITS THE OBSERVATION OF THE CHANGES TAKING PLACE WITHIN CELLS AS THEY ARE SUBJECTED TO A CENTRIFUGAL FORCE. THE CELL IS PLACED AT ONE END OF THE HOLLOW BAR AND IS WHIRLED ABOUT ON THE TURNTABLE. BY MEANS OF A SERIES OF LENSES AND MIRRORS WITHIN THE BAR THE IMAGE OF THE CELL IS CARRIED TO THE CENTER OF THE BAR SO THAT IT IS WITHIN THE RANGE OF THE SUSPENDED EYE-PIECE. THE SMALL MERCURY LIGHT, SEEN ABOVE THE END OF THE BAR, FLASHES ON THE REVOLVING CELL AS IT PASSES BENEATH, CREATING A SERIES OF IMAGES WHICH AFFORD THE OBSERVER A CONTINUOUS AND STEADY PICTURE OF THE CELL. THE PRINCIPLE IS SIMILAR TO THAT OF A MOTION PICTURE PROJECTOR.

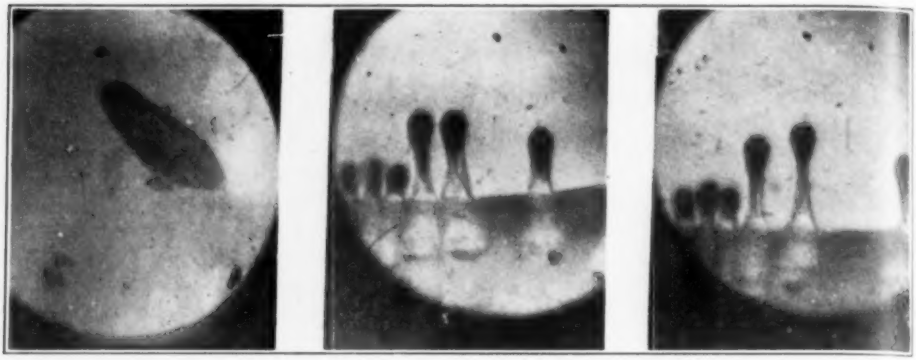
AN advance in biological knowledge is expected to result from the use of a new type of microscope which has been evolved by Dr. E. Newton Harvey, of Princeton University, and Alfred L. Loomis. By means of this instrument observations can be made upon the changes taking place within cells as they are subjected to centrifugal force. Preliminary calculations already made with the help of the new microscope indicate that existing ideas of some of the properties of matter within the cells will have to be revised.

Hitherto scientists have been handicapped in their study of cells by their inability to witness and measure the various steps in the deformation of cells and in the movement of particles within them when the cells are whirled rapidly about. Knowledge of what transpires when cells are subjected to centrifugal force has been based on deductions formed by examination of the cells before and after they have been in motion.

Although the cell is being whirled about at a rate of 10,000 revolutions a minute, the new microscope presents the observer with a clear, steady picture of it throughout the process. The principle is somewhat similar to that of a motion picture projector, with the whirling cell taking the place of the film and the eye of the observer the screen. The mechanism transmits to the eye a series of images with such regularity and rapidity that they blend into a steady, continuous picture.

In the new centrifuge-microscope a disc or turntable similar in size and operation to that in a phonograph is rotated at high speed by an electric motor. Mounted on the disc and extend-

AN AMOEBA IN ROTATION
Amoeba dubia INJECTED WITH OIL BY DR. D. A. MARSLAND, PHOTOGRAPHED THROUGH THE CENTRIFUGE-MICROSCOPE WHILE REVOLVING 10,000 REVOLUTIONS PER MINUTE. EXPOSURE 10 SECONDS.



PARAMECIUM AT REST AND IN ROTATION

PARAMECIUM FILLED WITH FAT GLOBULES PHOTOGRAPHED WITH CENTRIFUGE AT REST (LEFT) AND WHILE REVOLVING 10,000 REVOLUTIONS PER MINUTE FOR ONE MINUTE (CENTER) AND FOR FIVE MINUTES (RIGHT). NOTE THE BLACK MASS OF OIL ABOUT TO PULL OFF UNDER CENTRIFUGAL FORCE.

ing along its diameter is a hollow aluminum bar one half inch thick. In this narrow bar has been built the lower lens system of a microscope. This is contained beneath an aperture at one end of the bar and is near, consequently, the outer edge of the disc. Above this aperture is placed the slide holding the cell which is to be observed. By a proper arrangement of mirrors, the image is carried to the center of the bar and is reflected upward through a second aperture to the upper lenses and the eyepiece of the microscope. This working end of the microscope is supported directly over the center of the disc and is stationary.

This arrangement provides a means of constantly observing the cell when it is in motion, but the image, if it can be seen at all at rapid speed, is nothing but a blur. The problem of obtaining a clear image was solved by the adaptation of the principle of the motion picture projector. The solution consisted in catching a glimpse of the cell for a fraction of a second during its whirl and in making possible the repetition of that glimpse at frequent and regular intervals. Thus through the projection of a series of images, a continuous picture results.

This series of images is produced by flashing a light at regular intervals above the whirling disc. The light is so regulated that its flashes coincide with the passage of the cell beneath it. The flash lasts for about one one-millionth of a second. The speed of rotation of the disc controls the frequency of the flash. Standing away from the whirling disc and looking upon it, the observer is subject to an optical illusion. The disc does not appear to be moving at all and the bar seems to be stationary beneath the light. The flash is produced by a small mercury light, the duration and intermittency of which is controlled by the discharge of electricity through the mercury vapor.

The present microscope is capable of making 10,000 revolutions a minute. Its speed is limited by the resistance of the air to the hollow aluminum bar. In a new model the bar has been stream-lined to cut down this resistance and in cross-section it will have lines not unlike those of a racing automobile.

It is expected that this model will develop speeds of from 12,000 to 14,000 revolutions a minute. A speed of 12,000 revolutions will subject the cell to a centrifugal force 17,000 times greater than gravity. This may be compared to a pull of eight and one half tons upon an object which weighs one pound.